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THE STUDY OF SOCIOLOGY.

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V. *Objective Difficulties (continued).*

ANOTHER common cause of very serious perversion of evidence is the unconscious confounding of observation with inference. Everywhere, a fertile source of error is the putting down as something perceived what is really a conclusion drawn from something perceived; and this is a more than usually fertile source of error in Sociology. Here is an instance:

A few years ago Dr. Stark published the results of comparisons he had made between the rates of mortality among the married and among the celibate; showing, as it seemed, the greater healthfulness of married life. Some criticisms made upon his argument did not seriously shake it; and he has been since referred to as having conclusively proved the alleged relation. More recently I have seen quoted from the *Medical Press and Circular* the following summary of results supposed to tell the same tale:

"M. Bertillon has made a communication on this subject (the Influence of Marriage) to the Brussels Academy of Medicine, which has been published in the *Revue Scientifique*. From 25 to 30 years of age the mortality per 1,000 in France amounts to 6.2 in married men, 10.2 in bachelors, and 21.8 in widows. In Brussels the mortality of married women is 9 per 1,000, girls the same, and widows as high as 16.9. In Belgium, from 7 per 1,000 among married men, the number rises to 8.5 in bachelors and 24.6 in widows. The proportion is the same in Holland. From 8.2 in married men, it rises to 11.7 in bachelors, and 16.9 in widowers, or 12.8 among married women, 8.5 in spinsters, and 13.8 in widows. The result of all the calculations is that from 25 to 30 years of age the mortality per 1,000 is 4 in married men, 10.4 in bachelors, and 22 in widowers. This beneficial influence of marriage is manifested at all ages, being always more strongly marked in men than in women."

I will not dwell on the fallacy of the above conclusions as referring to the relative mortality of widows—a fallacy sufficiently obvious to any one who thinks awhile. I will confine myself to the less-conspicuous fallacy in the comparison between the mortalities of married and celibate, fallen into by M. Bertillon as well as Dr. Stark. Clearly as their figures seem to furnish proof of some direct causal relation between marriage and longevity, they really furnish no proof whatever. There may be such a relation; but the evidence assigned forms no warrant for inferring it.

We have but to consider a little the circumstances which in many cases determine marriage, and those which in other cases prevent marriage, to see that the connection which the figures apparently imply is not the real connection. Where attachments exist, what most frequently decides the question for or against marriage? The possession of adequate means. While some are so reckless as to marry without means, yet it is undeniable that in very many instances marriage is delayed by the man, or forbidden by the parents, or not assented to by the woman, until there is reasonable evidence of ability to meet the responsibilities. Of those men whose marriages depend on getting the needful income, which are the most likely to get the needful income? Those who are best, physically and mentally—the strong, the intellectually capable, the morally well-balanced. Often bodily vigor achieves a success, and therefore a revenue, which bodily weakness, unable to bear the stress of competition, cannot achieve. Often superior intelligence brings promotion and increase of salary, while stupidity lags behind in ill-paid posts. Often caution, self-control, and a far-seeing sacrifice of present to future, secure remunerative offices that are never given to the impulsive or the reckless. But, what are the effects of bodily vigor, of intelligence, of prudence, on longevity, when compared with the effects of feebleness, of stupidity, of deficient self-control? Obviously the first further the maintenance of life, and the second tend toward premature death. That is, the qualities which, on the average of cases, give a man an advantage in getting the means of marrying, are the qualities which make him likely to be a long-liver; and conversely.

There is even a more direct relation of the same general nature. In all creatures of high type, it is only when individual growth and development are nearly complete that the production of new individuals becomes possible; and the power of producing and bringing up new individuals is measured by the amount of vital power in excess of that needful for self-maintenance. The reproductive instincts, and all their accompanying emotions, become dominant when the demands for individual evolution are diminishing, and there is arising a surplus of energy which makes possible the rearing of offspring as well as the preservation of self; and, speaking generally, these instincts and emotions are strong in proportion as this surplus vital energy is great.

But to have a large surplus of vital energy implies a good organization, which is on the average of cases likely to last long. So that, in fact, the superiority of *physique* which is accompanied by strength of the instincts and emotions causing marriage is a superiority of *physique* also conducive to longevity.

One further influence tells in the same direction. Marriage is not altogether determined by the desires of men; it is determined in part by the preferences of women. Other things equal, women are attracted toward men of power—physical, emotional, intellectual; and obviously their freedom of choice leads them in many cases to refuse inferior samples of men; especially the malformed, the diseased, and those who are ill-developed, physically and mentally. So that, in so far as marriage is determined by female selection, the average result on men is that, while the best easily get wives, a certain proportion of the worst are left without wives. This influence, therefore, joins in bringing into the ranks of married men those most likely to be long-lived, and keeping in bachelorhood those least likely to be long-lived.

In three ways, then, does that superiority of organization which conduces to long life also conduce to marriage. It is normally accompanied by a predominance of the instincts and emotions prompting marriage; there goes along with it that power which can secure the means of making marriage practicable; and it increases the probability of success in courtship. The figures given afford no proof that marriage and longevity are cause and consequence; but they simply verify the inference which might be drawn *a priori*, that marriage and longevity are concomitant results of the same cause.

This striking instance of the way in which inference may be mistaken for fact, will sufficiently serve as a warning against another of the dangers that await us in dealing with sociological data. Statistics having shown that married men live longer than single men, it seems an irresistible implication that married life is healthier than single life. And yet we see that the implication is not at all irresistible: though such a connection may exist, it is not demonstrated by the evidence assigned. Judge, then, how difficult it must be, among those social phenomena where the dependencies are more entangled, to distinguish between the seeming relations and the real relations.

Once more, we are ever liable to be led away by superficial, trivial facts, from those deep-seated and really important facts which they indicate. Always the small details of social life, the interesting events, the curious things which serve for gossip, will, if we allow them, hide from us the vital connections and the vital actions underneath. Every social phenomenon results from an immense aggregate of general and special causes; and we may either take the phenomenon itself as intrinsically momentous, or, along with other phenomena, may take it as indicating some inconspicuous truth of real significance. Let us contrast the two courses.

Some months ago a correspondent of the *Times*, writing from Calcutta, said:

"The Calcutta University examinations of any year would supply curious material for reflection on the value of our educational systems. The prose test in the entrance examination this year includes 'Ivanhoe.' Here are a few of the answers which I have picked up. The spelling is bad, but that I have not cared to give:

"Question: 'Dapper man?' (Answer 1.) 'Man of superfluous knowledge.' (A. 2.) 'Mad.' (Q.) 'Democrat?' (A. 1.) 'Petticoat Government.' (A. 2.) 'Witchcraft.' (A. 3.) 'Half turning of the horse.' (Q.) 'Babylonish jargon?' (A. 1.) 'A vessel made at Babylon.' (A. 2.) 'A kind of drink made at Jerusalem.' (A. 3.) 'A kind of coat worn by Babylonians.' (Q.) 'Lay brother?' (A. 1.) 'A bishop.' (A. 2.) 'A step-brother.' (A. 3.) 'A scholar of the same godfather.' (Q.) 'Sumpter-mule?' (A.) 'A stubborn Jew.' (Q.) 'Bilious-looking fellow?' (A. 1.) 'A man of strict character.' (A. 2.) 'A person having a nose like the bill of an eagle.' (Q.) 'Cloister?' (A.) 'A kind of shell.' (Q.) 'Tavern politicians?' (A. 1.) 'Politicians in charge of the alehouse.' (A. 2.) 'Mere vulgars.' (A. 3.) 'Managers of the priestly church.' (Q.) 'A pair of cast-off galligaskins?' (A.) 'Two gallons of wine.'"

The fact here drawn attention to as significant is, that these Hindoo youths, during their matriculation examination, betrayed so much ignorance of the meanings of words and expressions contained in an English work they had read. And the intended implication appears to be that they were proved unfit to begin their college careers. If, now, instead of accepting that which is presented to us, we look a little below it, that which may strike us as more noteworthy is the amazing folly of an examiner who proposes to test the fitness of youths for commencing their higher education, by seeing how much they know of the technical terms, cant-phrases, slang, and even extinct slang, talked by the people of another nation. Instead of the unfitness of the boys, which is pointed out to us, we may see rather the unfitness of those concerned in educating them.

If, again, not dwelling on the particular fact underlying the one offered to our notice, we consider it along with others of the same class, our attention is arrested by the general fact that examiners, and more especially those appointed under recent systems of administration, habitually put questions of which a large proportion are utterly inappropriate. As I learn from his son, one of our judges not long since found himself unable to answer an examination-paper that had been put before law-students. A well-known Greek scholar, editor of a Greek play, who was appointed examiner, found that the examination-paper set by his predecessor was too difficult for him. Mr. Froude, in his inaugural address at St. Andrews, describing a paper set by an examiner in English history, said, "I could myself have answered two questions out of a dozen. And I learn from Mr. G. H. Lewes that he could not give replies to the questions on English literature which the Civil Service examiners had put to his son. Join-

ing which testimonies with kindred ones coming from students and professors on all sides, we find the really noteworthy thing to be that examiners are concerned not so much to set questions fit for students as to set questions which make manifest their own extensive learning. Especially if they are young, and have reputations to make or to justify, they seize the occasion for displaying their erudition, regardless of the interests of those they examine.

If we look through this more significant and general fact for the still deeper fact it grows out of, there rises before us the question—Who examines the examiners? How happens it that men, competent in their special knowledge but so incompetent in their general judgment, should occupy the places they do? This prevailing faultiness of the examiners shows conclusively that the administration is faulty at its centre. Somewhere or other, the power of ultimate decision is exercised by those who are unfit to exercise it. If the examiners of the examiners were set to fill up an examination-paper which had for its subject the right conduct of examinations, and the proper qualifications for examiners, there would come out very unsatisfactory answers.

Having seen through the small details and the wider facts down to these deeper facts, we may, on contemplating them, perceive that these, too, are not the deepest or most significant. It becomes clear that those having supreme authority suppose, as men in general do, that the sole essential thing for a teacher or examiner is complete knowledge of that which he has to teach, or respecting which he has to examine. Whereas a coessential thing is a knowledge of Psychology; and especially that part of Psychology which deals with the evolution of the faculties. Unless, either by special study or by daily observation and quick insight, he has gained an approximately-true conception of how minds perceive, and reflect, and generalize, and by what processes their ideas grow from concrete to abstract, and from simple to complex, no one is competent to give lessons that will effectually teach, or to ask questions which will effectually measure the efficiency of teaching. Further, it becomes manifest that, in common with the public at large, those in authority assume that the goodness of education is to be tested by the quantity of knowledge acquired. Whereas it is to be much more truly tested by the capacity for using knowledge—by the extent to which the knowledge gained has been turned into faculty, so as to be available both for the purposes of life and for the purposes of independent investigation. Though there is a growing consciousness that a mass of unorganized information is, after all, of but small value, and that there is more value in less information well organized, yet the noteworthy truth is that this consciousness has not got itself officially embodied; and that our educational administration is working, and will long continue to work, in pursuance of a crude and outworn belief.

As here, then, so in other cases meeting us in the present and all through the past, we have to contend with the difficulty that the greater part of the evidence supplied to us, as of chief interest and importance, is really of value only for what it indicates. We have to resist the temptation to dwell in those trivialities which make up nine-tenths of our records and histories; and which are worthy of attention solely because of the things they indirectly imply or the things tacitly asserted along with them.

Beyond those vitiations of evidence due to random observations, to the subjective states of the observers, to their enthusiasms, or prepossessions, or self-interests—beyond those that arise from the general tendency to set down as a fact observed what is really an inference from an observation, and also those that arise from the general tendency to omit the dissection by which small surface results are traced to large interior causes—there come those vitiations of evidence consequent on its distribution in Space. Of whatever class, political, moral, religious, commercial, etc., may be the phenomena we have to consider, a society presents them in so diffused and multitudinous a way, and under such various relations to us, that the conceptions we can frame are at best extremely inadequate.

Consider how impossible it is truly to conceive so relatively simple a thing as the territory which a society covers. Even by the aid of maps, geographical and geological, slowly elaborated by multitudes of surveyors—even by the aid of descriptions of towns, counties, mountainous and rural districts—even by the aid of such personal observations as we have made here and there in journeys during life; we can reach nothing approaching to a true idea of the actual varied surface—arable, grass-covered, wooded; flat, undulating, rocky; drained by rills, brooks, and slow rivers; sprinkled with cottages, farms, villas, cities. Imagination simply rambles hither and thither, and fails utterly to frame an adequate thought of the whole. How, then, shall we frame an adequate thought of a diffused moral feeling, of an intellectual state, of a commercial activity, pervading this territory; unaided by maps, and aided only by the careless statements of careless observers? Respecting most of the phenomena, considered as displayed by a whole nation, only the dimmest apprehensions are possible; and how untrustworthy they are, is shown by every parliamentary debate, by every day's newspapers, and by every evening's conversations; which severally disclose quite conflicting estimates.

See how various are the statements made respecting any nation in its character and actions by each traveller visiting it. There is a story, apt if not true, of a Frenchman who, having been three weeks here, proposed to write a book on England; who, after three months, found that he was not quite ready; and who, after three years, concluded that he knew nothing about it. And every one, who looks

back and compares his early impressions respecting states of things in his own society with the impressions he now has, will see how erroneous were the beliefs once so decided, and how probable it is that even his revised beliefs are but very partially true. On remembering how wrong he was in his preconceptions of the people and the life in some unvisited part of the kingdom—on remembering how different, from those he had imagined, were the characters he actually found in certain alien classes and along with certain alien creeds—he will see how greatly this wide diffusion of social facts impedes true appreciation of them.

Moreover, there are illusions consequent on what we may call moral perspective, which we do not habitually correct in thought, as we correct in perception the illusions of physical perspective. A small object close to, occupies a larger visual area than a mountain afar off; but here our well-organized experiences enable us instantly to rectify a false inference suggested by the subtended angles. No such prompt rectification for the perspective is made in sociological observations. A small event next door, producing a larger impression than a great event in another country, is over-estimated. Conclusions, prematurely drawn from social experiences daily occurring around us, are difficult to displace by clear proofs that elsewhere wider social experiences point to quite opposite conclusions.

A further great difficulty to which we are thus introduced is, that the comparisons of experiences, by which alone we can finally establish relations of cause and effect among social phenomena, can rarely be made between cases in all respects fit for comparison. Every society differs specifically, if not generically, from every other. Hence it is a peculiarity of the Social Science that parallels drawn between different societies do not afford grounds for decided conclusions—will not, for instance, show us with certainty what is an essential phenomenon in a given society and what is a non-essential one. Biology deals with numerous individuals of a species, and with many species of a genus, and by comparing them can see what traits are specifically constant and what generically constant; and the like holds more or less with the other concrete sciences. But comparisons between societies, among which we may almost say that each individual is a species by itself, yield much less definite results: the necessary characters are not thus readily distinguishable from the accidental characters.

So that, even supposing we have perfectly valid data for our sociological generalizations, there still lies before us the difficulty that these data are, in many cases, so multitudinous and diffused that we cannot adequately consolidate them into true conceptions; the additional difficulty, that the moral perspective under which they are presented can scarcely ever be so allowed for as to secure true ideas of proportions; and the further difficulty, that comparisons of our vague and incorrect conceptions concerning one society with our kindred

conceptions concerning another society, have always to be taken with the qualification that the comparisons are only partially justifiable, because the compared things are only partially alike in their other traits.

An objective difficulty, even greater still, which the Social Science presents, arises from the distribution of its facts in Time. Those who look on a society as either supernaturally created or created by Acts of Parliament, and who consequently consider successive stages of its existence as having no necessary dependence on one another, will not be deterred from drawing political conclusions from passing facts, by a consciousness of the slow genesis of social phenomena. But those who have risen to the belief that societies are gradually evolved in structure and function, as in growth, will be made to hesitate on contemplating the long unfolding through which early causes work out late results.

Even true appreciation of the successive facts which an individual life presents, is very generally hindered by inability to grasp the long-drawn processes by which ultimate effects are produced; as we may see in the foolish mother who, yielding to her perverse child, gains the immediate benefit of peace, and cannot be made to realize the evil of chronic dissension which her policy will hereafter bring about. And in the life of a nation, which, if of high type, lasts at least a hundred individual lives, correct estimation of results is still more hindered by this immense duration of the processes through which antecedents bring their consequents. In judging of political good and evil, the average legislator thinks much after the manner of the mother dealing with the spoiled child: if a course is productive of immediate benefit, that is considered sufficient justification. Quite recently an inquiry has been made into the results of an administration which had been in action some five years only, with the tacit assumption that, supposing the results were proved good, the administration would be justified.

And yet to those who look into the records of the past not to revel in narratives of battles or to gloat over court-scandals, but to find how institutions and laws have arisen and how they have worked, there is no truth more obvious than that generation after generation must pass before you can see what is the outcome of an action that has been set up. Take the example furnished us by our Poor-Laws. When villeinage had passed away and serfs had no longer to be maintained by their owners—when, in the absence of any one to control and take care of serfs, there arose an increasing class of mendicants and "sturdy rogues, preferring robbery to labor"—when, in Richard the Second's time, authority over such was given to justices and sheriffs, out of which there presently grew the binding of servants, laborers, and beggars, to their respective localities—when, to meet the case of beggars, "impotent to serve," the people of the districts in which they

were found were made in some measure responsible for them (so, re-introducing in a more general form the feudal arrangement of attachment to the soil, and reciprocal claim on the soil)—it was not suspected that the foundations were laid for a system which would, in after-times, bring about a demoralization threatening general ruin. When, in subsequent centuries, to meet the evils of again-increasing vagrancy which punishment failed to repress, these measures, reënacted with modifications, ended in making the people of each parish chargeable with the maintenance of their poor, while it reëstablished the severest penalties on vagabondage, even to death without benefit of clergy, no one ever anticipated that, while the penal elements of this legislation would by-and-by become so mollified as to have little practical effect in checking idleness, the accompanying arrangements would eventually take such forms as immensely to encourage idleness. Neither legislators nor others foresaw that in 230 years the poor's-rate, having grown to seven millions, would become a public spoil of which we read that—

"The ignorant believed it an inexhaustible fund which belonged to them. To obtain their share the brutal bullied the administrators, the profligate exhibited their bastards which must be fed, the idle folded their arms and waited till they got it; ignorant boys and girls married upon it; poachers, thieves, and prostitutes, extorted it by intimidation; country justices lavished it for popularity, and guardians for convenience. . . . Better men sank down among the worse; the rate-paying cottager, after a vain struggle, went to the pay-table to seek relief; the modest girl might starve while her bolder neighbor received 1*s.* 6*d.* per week for every illegitimate child."

As sequences of the law of Elizabeth, no one imagined that, in rural districts, farmers, becoming chief administrators, would pay part of their men's wages out of the rates (so taxing the rest of the rate-payers for the cultivation of their fields); and that this abnormal relation of master and man would entail bad cultivation. No one imagined that, to escape poor's-rates, landlords would avoid building cottages, and would even clear cottages away; so causing overcrowding, with consequent evils, bodily and mental. No one imagined that workhouses, so called, would become places for idling in; and places where married couples, habitually residing, displayed their "elective affinities" time after time.[1] Yet these, and detrimental results which it would take pages to enumerate, culminating in that general result most detrimental of all—helping the worthless to multiply at the expense of the worthy—finally came out of these measures taken ages ago merely to mitigate certain immediate evils.

Is it not obvious, then, that only in the course of those long periods

[1] In one case, "out of thirty married couples, there was not one man then living with his own wife, and some of them had exchanged wives two or three times since their entrance." This, along with various kindred illustrations, will be found in tracts on the Poor-Law, by a late uncle of mine, the Rev. Thomas Spencer, of Hinton Charterhouse, who was chairman of the Bath Union during its first six years.

required to mould national characters and habits and sentiments, will the truly important results of a public policy show themselves? Let us consider the question a little further.

In a society living, growing, changing, every new factor becomes a permanent force; modifying more or less the direction of movement determined by the aggregate of forces. Never simple and direct, but, by the coöperation of so many causes, made irregular, involved, and always rhythmical, the course of social change can never be judged of in its general direction by inspecting any small portion of it. Each action will inevitably be followed, after a while, by some direct or indirect reaction, and this again by a re-reaction; and, until the successive effects have shown themselves, it is impossible to say how the total motion will be modified. You must compare positions at great distances from one another in time, before you can perceive rightly where things are tending. Even so simple a thing as a curve of single curvature cannot have its nature determined unless there is a considerable length of it. See here these four points close together. The curve passing through them may be a circle, an ellipse, a parabola, an hyperbola; or it may be a catenarian, a cycloid, a spiral. Let the points be farther apart, and it becomes possible to form some opinion of the nature of the curve—it is obviously not a circle. Let them be more remote still, and it may be seen that it is neither an ellipse nor a parabola. And, when the distances are relatively great, the mathematician can say with certainity what curve alone will pass through them all. Surely, then, in such complex and slowly-evolving movements as those of a nation's life, all the smaller and greater rhythms of which fall within certain general directions, it is impossible that such general directions can be traced by looking at stages that are close together—it is impossible that the effect wrought on any general direction, by some additional force, can be truly computed from observations extending over but a few years, or but a few generations.

For, in the case of these most-involved of all movements, there is the difficulty, paralleled in no other movements (being only approached in those of individual evolution), that each new factor, besides affecting in an immediate way the course of a movement, affects it also in a remote way by changing the amounts and directions of all other factors. A fresh influence brought into play on a society not only affects its members directly in their acts, but also indirectly in their characters. Continuing to work on their characters generation after generation, and modifying by inheritance the feelings which they bring into social life at large, this influence alters the intensities and bearings of all other influences throughout the society. By slowly initiating modifications of Nature, it brings into play forces of many kinds, incalculable in their strengths and tendencies, that act without regard to the original influence, and may produce quite opposite effects.

Fully to exhibit this objective difficulty, and to show more clearly still how important it is to take as our data for sociological conclusions, not the brief sequences, but the sequences that extend over centuries or are traceable throughout civilization, let us draw a lesson from a trait which all regulative agencies in all nations have displayed.

The original meaning of human sacrifices, which is otherwise tolerably clear, becomes quite clear on finding that where cannibalism is still rampant, and where the largest consumers of human flesh are the chiefs, these chiefs, undergoing apotheosis when they die, are believed thereafter to feed on the souls of the departed—the souls being regarded as duplicates equally material with the bodies they belong to. And, should any doubt remain, it must be dissipated by the accounts we have of the ancient Mexicans, whose priests, when war had not lately furnished a victim, complained to the king that the god was hungry; and who, when a victim was sacrificed, offered his heart to the idol (bathing its lips with his blood, and even putting portions of the heart into its mouth), and then cooked and ate the rest of the body themselves. Here the fact of significance to which attention is drawn, and which various civilizations show us, is that the sacrificing of prisoners or others, once a general usage among cannibal ancestry, continues as an ecclesiastical usage long after having died out in the ordinary life of a society. Two facts, closely allied with this fact, have like general implications. Cutting implements of stone remain in use for sacrificial purposes when implements of bronze, and even of iron, are used for all other purposes. Further, the primitive method of obtaining fire, by the friction of pieces of wood, survives in religious ceremonies ages after its abandonment in the household; and even now, among the Hindoos, the flame for the altar is kindled by the "fire-drill." These are striking instances of the pertinacity with which the oldest part of the regulative organization maintains its original traits in the teeth of influences that modify things around it.

The like holds in respect of the language, spoken and written, which it employs. Among the Egyptians the most ancient form of hieroglyphics was retained for sacred records, when more developed forms were adopted for other purposes. The continued use of Hebrew for religious services among the Jews, and the continued use of Latin for the Roman Catholic service, show us how strong this tendency is, apart from the particular creed. Among ourselves, too, a less dominant ecclesiasticism exhibits a kindred trait. The English of the Bible is of an older style than the English of the date at which the translation was made; and in the church service various words retain obsolete meanings, and others are pronounced in obsolete ways. Even the typography, with its illuminated letters of the rubric, shows traces of the same tendency; while Puseyites and ritualists, aiming to reënforce ecclesiasticism, betray a decided leaning toward archaic print, as well as archaic ornaments. In the æsthetic direction, indeed, their move-

ment has brought back the most primitive type of sculpture for monumental purposes; as may be seen in Canterbury Cathedral, where, in two new monuments to ecclesiastics, one being Archbishop Sumner, the robed figures recline on their backs, with hands joined, after the manner of the mailed knights on early tombs—presenting complete symmetry of attitude, which is a distinctive trait of barbaric art, as every child's drawing of a man and every idol carved by a savage shows us.

A conscious as well as an unconscious adhesion to the old in usage and doctrine is shown. Not only among Roman Catholics, but among many Protestants, to ascertain what the Fathers said, is to ascertain what should be believed. In the pending controversy respecting the Athanasian Creed, we see how much authority attaches to an antique document. The antagonism between Convocation and the lay members of the Church—the one as a body wishing to retain the cursing clauses and the other to exclude them—further shows that official Protestantism adheres to antiquity much more than non-official Protestantism: a contrast equally displayed not long since between the opinions of the lay part and the clerical part of the Protestant Irish Church.

Throughout political organizations the like tendency, though less dominant, is very strong. The gradual establishment of law, by the consolidation of custom, is the formation of something fixed in the midst of things that are changing; and, regarded under its most general aspect as the agency which maintains a permanent order, it is in the very nature of a State-organization to be relatively rigid. The way in which primitive principles and practices, no longer fully in force among individuals ruled, survive in the actions of ruling agents, is curiously illustrated by the long retention between nobles of a right of feud after it had been disallowed between citizens. Chief vassals, too, retained this power to secure justice for themselves after smaller vassals lost it: not only was a right of war with one another recognized, but also a right of defence against the king. And we see that even now, in the relations between Governments, there persists that use of force to remedy injuries, which originally existed between all individuals. As bearing in the same direction, it is significant that the right of trial by battle, which was a regulated form of the aboriginal system under which men administered justice in their own cases, survived among the ruling classes when no longer legal among inferior classes. Even on behalf of religious communities judicial duels were fought. Here the thing it concerns us to note is, that the system of fighting in person and fighting by deputy, when no longer otherwise lawful, remained in force, actually or formally, in various parts of the regulative organization. Up to the reign of George III., trial by battle could be claimed as an alternative of trial by jury. Duels continued till quite recently between members of the ruling classes, and

especially between officers; and even now in Continental armies duelling is not only recognized as proper, but is, in some cases, imperative. And then, showing most curiously how in connection with the oldest part of the governing organization these oldest usages survive longest, we have, in the coronation ceremony, a champion in armor uttering by herald a challenge to all comers on behalf of the monarch.

If, from the agencies by which law is enforced, we pass to legal forms, language, documents, etc., the like tendency is everywhere conspicuous. Parchment is retained for law-deeds, though paper has replaced it for other purposes. The form of writing is an old form. Latin and Norman-French terms are still in use for legal purposes, though not otherwise in use; and even old English words, such as "seize," retain, in Law, meanings which they have lost in current speech. In the execution of documents, too, the same truth is illustrated; for the seal, which was originally the signature, continues, though the written signature now practically replaces it—nay, we retain a symbol of the symbol, as may be seen in every share-transfer, where there is a paper-wafer to represent the seal. Even still more antique usages survive in legal transactions; as in the form extant in Scotland of handing over a portion of rock when an estate is sold, which evidently answers to the ceremony among the ancient nations of sending earth and water as a sign of yielding territory.

From the working of State-departments, too, many kindred illustrations might be given. Even under the peremptory requirements of national safety, the flint-lock for muskets was but tardily replaced by the percussion-lock; and it was generations after the rifle had been commonly in use for sporting purposes before it came into more than sparing use for military purposes. Book-keeping by double entry had long been permanently established in the mercantile world before it superseded book-keeping by single entry in Government offices—its adoption dating back only to 1834, when a still more antique system of keeping accounts, by notches cut on sticks, was put an end to by the conflagration that resulted from the burning of the Exchequer tallies.

The like holds with apparel, in general and in detail. Cocked hats are yet to be seen on the heads of officers. An extinct form of dress still holds its ground as the court-dress; and the sword once habitually worn by gentlemen has become the dress-sword worn only on State-occasions. Everywhere officialism has its established uniforms, which may be traced back to old fashions that have disappeared from ordinary life. Some of these antique articles of costume we see surmounting the heads of judges; others there are which still hang round the necks of the clergy; and others which linger on the legs of bishops.

Thus, from the use of a flint-knife by the Jews for the religious ceremony of circumcision, down to the pronunciation of the terminal

syllable of the præterite in our Church service, down to the *oyez* shouted in a law-court to secure attention, down to the retention of epaulets for officers, and down to the Norman-French words in which the royal assent is given, this persistence is everywhere traceable. And when we find this persistence manifested throughout all ages in all departments of the regulative organization—when we see it to be the natural accompaniment of the function of that organization, which is essentially restraining—when we estimate the future action of the organization in any case, by observing the general sweep of its curve throughout long periods of the past—we shall see how misleading may be the conclusions drawn from recent facts taken by themselves. Where the regulative organization is anywhere made to undertake additional functions, we shall not form sanguine anticipations on the strength of immediate results of the desired kind; but we shall suspect that, after the phase of early activity has passed by, the plasticity of the new structure will rapidly diminish, the characteristic tendency toward rigidity will begin to show itself, and in place of a progressive effect there will come a restrictive effect.

The reader will now understand more clearly the meaning of the assertion that true conceptions of sociological changes are to be reached only by contemplating their slow genesis through centuries; and that basing inferences on results shown in short periods is as illusory as would be judging of the Earth's curvature by observing whether we are walking up or down hill. After recognizing which truth he will perceive how great is another of the obstacles in the way of the Social Science.

"But does not all this prove too much? If it is so difficult to get sociological evidence that is not vitiated by the subjective states of the witnesses, by their prejudices, enthusiasms, interests, etc.—if, where there is impartial examination, the conditions of the inquiry are of themselves so apt to falsify the result—if there is so general a proneness to assert as facts observed what were really inferences from observations, and so great a tendency also to be blinded by exterior trivialities to interior essentials—if, even where accurate data are accessible, their multitudinousness and diffusion in Space make it impracticable clearly to grasp them as wholes, while their unfolding in Time is so slow that antecedents and consequents cannot be mentally represented in their true relations—is it not manifestly impossible that a Social Science can be framed?"

It must be admitted that the array of objective difficulties thus brought together is formidable; and were it the aim of the Social Science to draw quite special and definite conclusions, which must depend for their truth upon exact data accurately coördinated, it would obviously have to be abandoned. But there are certain classes of general facts which remain after all errors in detail, however pro-

duced, have been allowed for. Whatever conflicts there may be among accounts of events that occurred during the feudal ages, comparison of them brings out the incontestable truth that there was a Feudal System. By implication, chronicles and laws indicate the traits of this system; and on putting side by side narratives and documents written, not to tell us about the Feudal System but for quite other purposes, we get tolerably clear ideas of these traits in their essentials—ideas made clearer still on collating the evidence furnished by different contemporary societies. Similarly throughout. By making due use not so much of that which past and present witnesses intend to tell us, as of that which they tell us by implication, it is possible to collect data for inductions respecting social structures and functions in their origin and development: the obstacles which arise in the disentangling of such data in the case of any particular society being mostly surmountable by the help of the comparative method.

Nevertheless, the difficulties that have been enumerated must be ever present to us. Throughout, we hope to depend on testimony; and in every case we have to beware of the many modes in which evidence may be vitiated—have to estimate its worth when it has been discounted in various ways; and have to take care that our conclusions do not depend upon any particular class of facts gathered from any particular place or time.

EPIDEMIC DELUSIONS.

BY DR. CARPENTER, F.R.S., LL.D.

A LECTURE, DELIVERED IN THE HULME TOWN-HALL, MANCHESTER.

OUR subject to-night links itself in such a very decided manner to the subject in which we were engaged last week, and the illustrations which I shall give you are so satisfactorily explained on the scientific principle which I endeavored then to expound to you, that I would spend a very few minutes in just going over some of the points to which I then particularly directed your attention. My object was to show you that, between our Mental operations and our Will, there is something of that kind of relation which exists between a well-trained horse and his rider; that the Will—if rightly exercised in early infancy in directing and controlling the mental operations; in directing the attention to the objects to which the intellect should be applied; in controlling and repressing emotional disturbance; restraining the feelings when unduly excited, and putting a check upon the passions—that the will in that respect has the same kind of influence

over the mind, or ought to have, as the rider has upon his horse; that the powers and activities of the mind are to a very great degree independent of the will; that the mind will go on of itself without any more than just the starting of the will, in the same manner as a horse will go on in the direction that it has been accustomed to go with merely the smallest impulse given by the voice, or the hand, or the heel of the rider, and every now and then a very slight check (if it is a well-trained horse) or guidance from the bridle, or from a touch of the spur, and will follow exactly the course that the rider desires, but by its own independent power. And, again, I showed you that as there are occasions on which a horse is best left to itself, so there are occasions when the mind is best left to itself, without the direction and control of the will; in fact, in which the operations of the mind are really disturbed by being continually checked and guided and pulled up by the action of the will, the result being really less satisfactory than when the mind, previously trained and disciplined in that particular course of activity, is left to itself. I gave you some curious illustrations of this from occurrences which have taken place in Dreaming, or in that form of dreaming which we call Somnambulism: where a legal opinion had been given, or a mathematical problem had been resolved, in the state of sleep-waking; that is to say, the mind being very much in the condition of that of the dreamer, its action being altogether automatic, going on of itself without any direction or control from the will—but the bodily activity obeying the direction of the mind. And then I went on to show you that this activity very often takes place, and works out most important results, even without our being conscious of any operations going on; and that some of these results are the best and most valuable to us in bringing at last to our consciousness, ideas which we have been vainly searching for—as in the case where we have endeavored to remember something that we have not at first been able to retrace, and which has flashed into our minds in a few hours, or it may be a day or two afterward; or, again, when we have been directing our minds to the solution of some problem which we have put aside in a sort of despair, and yet in the course of a little time that solution has presented itself while our minds have either been entirely inactive, as in sleep, or have been directed into some entirely different channel of action.

Now, like the well-trained horse which will go on of itself with the smallest possible guidance, yet still under the complete domination of the rider, and will even find its way home when the rider cannot direct it thither, we find that the human mind sometimes does that which even a well-trained horse will do—that it runs away from the guidance of its directing will. Something startles the horse, something gives it alarm; and it makes a sudden bound, and then, perhaps, sets off at a gallop, and the rider cannot pull it up. This alarm often spreads contagiously, as it were, from one horse to another, as we

lately saw in the "stampede" at Aldershot. Or, again, a horse, even if well trained, when he gets a new rider, sometimes, as we say, "tries it on," to see whether the horse or the rider is really the master. I have heard many horsemen say that that is a very familiar experience. When you first go out with a new horse, it may be to a certain degree restive; but if the horse finds that you keep a tight hand upon him, and that his master knows well how to keep him under control, a little struggling may have to be gone through, and the horse from that time becomes perfectly docile and obedient. But, if, on the other hand, the horse finds that *he* is the master, even for a short time, no end of trouble is given afterward to the rider in acquiring that power which he desires to possess. Now, that is just the case with our minds; we may follow out the parallel very closely indeed. We find that if our minds once acquire habits—habits of thought, habits of feeling—which are independent of the will, which the will has not kept under adequate regulation, these habits get the better of us; and then we find that it is very difficult indeed to recover that power of self-direction which we have been aiming at, and which the well-trained and well-disciplined mind will make its highest object. So, again, we find that there are states in which, from some defect in the physical condition of the body, or it may be from some great shock which has affected the mind and weakened for a time the power of the will, very slight impulses—just like the slight things that will make a horse shy—will disturb us unduly; and we feel that our emotions are excited in a way that we cannot account for, and we wonder why such a little thing should worry and vex us in the way that it does. Even the best of us know, within our own personal experience, that when we are excessively fatigued in body, or overstrained in mind, our power of self-control is very much weakened; so that particular ideas will take possession of us, and for a time will guide our whole course of thought, in a manner which our sober judgment makes us feel to be very undesirable. What, for instance, is more common than for a person to take offence at something that has been said or done by his most intimate friend, or by some member of his family; merely because he has been jaded or overtasked, and has not the power of bringing to the fair judgment of his common-sense the question whether that offence was really intended, or whether it was a thing he ought not to take any notice of? He broods over this notion, and allows it to influence his judgment; and, if he does not in a day or two rouse himself and master his feelings by throwing it off, it may give rise to a permanent estrangement. We are all of us conscious of states of mind of that kind.

But there are states of mind which lead to very much more serious disorder, arising from the neglect of that primary discipline and culture on which I have laid so much stress. We find that ignorance, and that want of the habit of self-control which very commonly ac-

companies it, predispose very greatly indeed to the violent excitement of the feelings, and to the possession of the mind by ideas which we regard as essentially absurd; and under these states of excitement of feeling, and the tendency of these dominant ideas to acquire possession of the intellect, the strangest aberrations take place, not only in individuals but in communities; and it is of such that I have especially to speak to-night. We know perfectly well, in our individual experience, that these states tend to produce insanity if they are indulged in, and if the individual does not make an earnest effort to free himself from their influence. But, looking back at the history of the earlier ages, and carrying that survey down to the present time, we have experience in all ages of great masses of people being seized upon by these dominant ideas, accompanied with the excitement of some passion or strong impulse which leads to the most absurd results; and it is of these Epidemic Delusions I have to now speak. The word "epidemic" simply means something that falls upon, as it were, the great mass of the people—a delusion which affects the popular mind. And I believe that I can best introduce the subject to you by showing you how, in certain merely physical conditions, mere bodily states, there is a tendency to the propagation, by what is commonly called imitation, of very strange actions of the nervous system. I suppose there is no one of you who does not know what an hysteric fit means, a kind of fit to which young women are especially subject, but which affects the male sex also. One reason why young women are particularly subject to it is, that in the female the feelings are more easily excited, while the male generally has a less mobile nervous system, his feelings being less easily moved, while he is more influenced by the intellect. These hysteric fits are generally brought on by something that strongly affects the feelings. Now, it often happens that a case of this sort presents itself in a school or nunnery, sometimes in a factory where a number of young women are collected together; one being seized with a fit, others will go off in a fit of a very similar kind. There was an instance a good many years ago in a factory in a country town in Lancashire, in which a young girl was attacked with a violent convulsive fit, brought on by alarm, consequent upon one of her companions, a factory operative, putting a mouse down inside her dress. The girl had a particular antipathy to mice, and the sudden shock threw her into a violent fit. Some of the other girls who were near very soon passed off into a similar fit; and then there got to be a notion that these fits were produced by some emanations from a bale of cotton; and the consequence was that they spread, till scores of the young women were attacked day after day with these violent fits. The medical man who was called in saw at once what the state of things was; he assured them in the first place that this was all nonsense about the cotton; and he brought a remedy, in the second place, which was a very appropriate one under the circumstance—namely,

an electrical machine; and he gave them some good violent shocks, which would do them no harm, assuring them that this would cure them. And cure them it did. There was not another attack afterward. I remember very well that when I was a student at Bristol, there was a ward in the hospital to which it was usual to send young servant-girls; for it was thought undesirable that these girls should be placed in the ward with women of a much lower class, especially the lower class of Irishwomen who inhabited one quarter of Bristol, as I believe there is an Irish quarter in Manchester. These girls were mostly respectable, well-conducted girls, and it was thought better that they should be kept together. Now, the result of this was that, if an hysteric fit took any one of them, the others would follow suit; and I remember perfectly well, when I happened to be a resident pupil, having to go and scold these girls well, threatening them with some very severe infliction. I forget what was threatened, perhaps it would be a shower-bath, for any one who went off into one of these fits. Now, here the cure is effected by a stronger emotion, the emotion of the dread of—we will not call it punishment—but of a curative measure; and this emotion overcame the tendency to what we commonly call imitation. It is the suggestion produced by the sight of one, that brings on the fit in another, where there is the predisposition to it. Now, I believe that in all these cases there is something wrong in the general health or in the nervous system; or the suggestion would not produce such results. Take the common teething-fits of children. We there see an exciting cause in the cutting of the teeth; the pressure of the tooth against the gum being the immediate cause of the production of convulsive action. But it will not do so in the healthy child. I feel sure that in every case where there is a teething-fit, of whatever kind, there is always some unhealthy condition of the nervous system—sometimes from bad food; more commonly from bad air. I have known many instances in which children had fits with every tooth that they cut, yet when sent into the country they had no recurrence of the fit. There must have been some predisposition, some unhealthy condition of the nervous system, to favor the exciting cause, which, acting upon this predisposition, brings out such very unpleasant results.

There are plenty of stories of this kind that I might relate to you. For instance, in nunneries it is not at all uncommon, from the secluded life, and the attention being fixed upon one subject, one particular set of ideas and feelings—the want of a healthy vent, so to speak, for the mental activity—that some particular odd propensity has developed itself. For instance, in one nunnery abroad, many years ago, one of the youngest nuns began to mew like a cat; and all the others, after a time, did the same. In another nunnery one began to bite, and the others were all affected with the propensity to bite. In one of these instances the mania was spreading like wild-fire through Germany, ex-

tending from one nunnery to another; and they were obliged to resort to some such severe measures as I have mentioned to drive it out. It was set down in some instances to demoniacal possession, but the devil was very easily exorcised by some pretty strong threat on the part of the medical man. The celebrated physician Boerhaave was called in to a case of that kind in an orphan asylum in Holland, and I think his remedy was a red-hot iron. He heated the poker in the fire, and said that the next girl who fell into one of these fits should be burnt in the arm; this was quite sufficient to stop it. In Scotland at one time there was a great tendency to breaking out into fits of this kind in the churches. This was particularly the case in Shetland; and a very wise minister there told them that the thing could not be permitted, and that the next person who gave way in this manner—as he was quite sure they could control themselves if they pleased—should be taken out and ducked in a pond near. There was no necessity at all to put his threat into execution. Here, you see, the stronger motive is substituted for the weaker one, and the stronger motive is sufficient to induce the individual to put a check upon herself. I have said that it usually happens with the female sex, though sometimes it occurs with young men who have more or less of the same constitutional tendency. What is necessary is to induce a stronger motive, which will call forth the power of self-control which has been previously abandoned.

Now, this tendency, which here shows itself in convulsive movements of the body, will also show itself in what we may call convulsive action of the Mind; that is, in the excitement of violent feelings and even passions, leading to the most extraordinary manifestations of different kinds. The early Christians, you know, practised self-mortification to a very great degree; and considered that these penances were so much scored up to the credit side of their account in heaven; that, in fact, they were earning a title to future salvation by self-mortification. Among other means of self-mortification, they scourged themselves. That was practised by individuals. But in the middle ages this disposition to self-mortification would attack whole communities, especially under the dominant idea that the world was coming to an end. In the middle of the thirteenth century, about 1250, there was this prevalent idea that the world was coming to an end; and whole communities gave themselves up to this self-mortification by whipping themselves. These Flagellants went about in bands with banners, and even music, carrying scourges; and then, at a given signal, every one would strip off the upper garment (men, women, and children joined these bands), and proceed to flog themselves very severely indeed, or to flog each other. This subsided for a time, but it broke out again during and immediately after that terrible plague which is known as the "black death," which devastated Europe in the reign of Edward III., about the year 1340. This black death seems to have been the Eastern plague in a very severe form, which we have

not known in this country since the great plague of London in Charles II.'s time, and one or two smaller outbreaks since, but which has now entirely left us. The severity of this plague in Europe was so great that upon a very moderate calculation one in four of the entire population was carried off by it; and in some instances it is said that nine-tenths of the people died of it. You may imagine, therefore, what a terrible infliction it was. And you would have supposed that it would have called forth the better feelings of men and women generally; but it did not. One of the worst features, morally, of that terrible affliction, was the lamentable suspension of all natural feelings which it seemed to induce. When any member of a family was attacked by this plague, every one seemed to desert him, or desert her; the sick were left to die alone, or merely under the charge of any persons who thought that they would be paid for rendering this service; and the funerals were carried on merely by these paid hirelings in a manner most repulsive to the feelings: and yet the very people who so deserted their relatives would join the bands of flagellants, who paraded about from place to place, and even from country to country—mortifying their flesh in this manner for the purpose of saving their own souls, and, as they said, also making expiation for the great sins which had brought down this terrible visitation. This system of flagellation never gained the same head in this country that it did on the Continent. A band of about 100 came to London about the middle of the reign of Edward III., in the year 1350. They came in the usual style, with banners and even instruments of music, and they paraded the streets of London. At a given signal every one lay down and uncovered the shoulders, excepting the last person, who then flogged every one till he got to the front, where he lay down; and the person last in the rear stood up, and in his turn flogged every one in front of him. Then he went to the front and lay down; and so it went on until the whole number had thus been flogged, each by every one of his fellows. This discipline however, did not approve itself to the good citizens of London, and it is recorded that the band of flagellants returned without having made any converts. Whether the skins of the London citizens were too tender, or whether their good sense prevailed over this religious enthusiasm, we are not informed; at any rate, the flagellants went back very much as they came, and the system never took root in this country; yet for many years it was carried on elsewhere. One very curious instance is given of the manner in which it fastened on the mind—that mothers actually scourged their new-born infants before they were baptized, believing that in so doing they were making an offering acceptable to God. Now all this appears to us perfectly absurd. We can scarcely imagine the state of mind that should make any sober, rational persons suppose that this could be an offering acceptable to Almighty God; but it was in accordance with the religious ideas of the time; and for a good while even the Church sanctioned

and encouraged it, until at last various moral irregularities grew up, of a kind that made the Pope think it a very undesirable thing, and it was then put down by ecclesiastical authority; yet it was still practised in secret for some time longer, so that it is said that even until the beginning of the last century there were small bands of flagellants in Italy, who used to meet for this self-mortification.

That was one form in which a dominant idea took possession of the mind and led to actions which might be called voluntary, for they were done under this impression, that such self-mortification was an acceptable offering. But there were other cases in which the action of the body seemed to be in a very great degree involuntary, just about as involuntary as an hysteric fit, and yet in which it was performed under a very distinct idea; such was what was called the "Dancing Mania," which followed upon this great plague. This dancing mania seemed in the first instance to seize upon persons who had a tendency to that complaint which we now know as St. Vitus's dance—St. Vitus was, in fact, the patron saint of these dancers. St. Vitus's dance, or chorea, in the moderate form in which we now know it, is simply this, that there is a tendency to jerking movements of the body, these movements sometimes going on independently of all voluntary action, and sometimes accompanying any attempt at voluntary movement; so that the body of a person may be entirely at rest until he desires to execute some ordinary movement, such as lifting his hand to his head to feed himself, or getting up to walk; then, when the impulse is given to execute a voluntary movement, instead of the muscles obeying the will, the movement is complicated (as it were) with violent jerking actions, which show that there is quite an independent activity. The fact is, that stammering is a sort of chorea. We give the name of chorea to this kind of disturbance of the nervous system, and the action of stammering is a limited chorea—chorea limited to the muscles concerned in speech, when the person cannot regulate the muscles so as to bring out the words desired; the very strongest effort of his will cannot make the muscles obey him, but there is a jerking, irregular action every time he attempts to pronounce particular syllables. And the discipline that the stammerer has to undergo in order to cure or alleviate his complaint is just the kind of discipline I have spoken of so frequently—the fixing the attention on the object to be gained, and regularly exercising the nerves and muscles in proceeding from that which they *can* do to that which they find a difficulty in doing. That is an illustration of the simpler form of this want of definite control over the muscular apparatus, connected with a certain mental excitement; because every one knows that a stammerer is very much affected by the condition of his feelings at the time. If, for example, he is at all excited, or if he apprehends that he shall stammer, that is enough to produce it. I have known persons who never stammered in ordinary conversation, yet when in company with stammerers they could

scarcely avoid giving way to it; and even when the subject of stammering was talked about, when the idea was conveyed to their minds, they would begin to hesitate and stutter, unless they put a very strong control upon themselves. It is just in this way, then, only in the most exaggerated form, that these persons were afflicted with what was called the dancing mania. They would allow themselves to be possessed with the idea that they *must* dance; and this dancing went on, bands going from town to town, and taking in any who would join them. Instances are recorded in which they would go on for twenty-four or thirty-six hours, continually dancing and jumping and exerting themselves in the most violent manner, taking no food all this time, until at last they dropped on the ground almost lifeless; and in fact several persons, it is said, did die from pure exhaustion, and this just because they were possessed with the idea that they *must* dance. They were drawn in, as it were, by the contagion of example; and, when once they had given way to it, they did not seem to know when to stop. This was kept up by music and by the encouragement and excitement of the crowd around; and it spread among classes of persons who (it might be supposed) would have had more power of self-restraint, and would not have joined such unseemly exhibitions. The extraordinary capacity, as it were, for enduring physical pain, was one of the most curious parts of this condition. They would frequently ask to be struck violently; would sometimes lie down, and beg persons to come and thump and beat them with great force. They seemed to enjoy this.—In another case that I might mention this was shown still more. The case was of a similar type, but was connected more distinctly with the religious idea, and it occurred much more recently. The case was that known in medical history as the Convulsionnaires of St.-Médard. There was a cemetery in Paris in which a great saint had been interred, and some young women visiting his tomb had been thrown into a convulsive attack which propagated itself extensively; and these convulsionnaires spreading the contagion, as it were, into different classes of French society, one being seized after another till the number became very great in all grades. Here, again, one of the most curious things was the delight they seemed to take in what would induce in other persons the most violent physical suffering. There was an organized band of attendants, who went about with clubs, and violently beat them. This was called the *grand secours*, which was administered to those who were subject to these convulsive attacks. You would suppose that these violent blows with the clubs would do great mischief to the bodies of these people; but they only seemed to allay their suffering.

This, then, is another instance of the mode in which this tendency to strange actions under the dominance of a particular idea will spread through a community. Here you have the direct operation of the perverted mind upon the body. But there are a great many cases in

which the perversion shows itself more in the mental state alone, leading to strange aberrations of Mind, and ultimately to very sad results in the condition of society where these things have spread, but not leading to any thing like these convulsive paroxysms. I particularly allude now to the epidemic belief in Witchcraft, which, more or less, formerly prevailed constantly among the mass of the population, but every now and then broke out with great vehemence. This belief in witchcraft comes down to us from very ancient periods; and at the present time it is entertained by the lowest and most ignorant of the population in all parts of the world. We have abundant instances of it still, I am sorry to say, in our own community. We have poor, ignorant servant-girls allowing themselves to be—if I may use such a word—"humbugged" by some designing old woman, who persuades them that she can predict the husbands they are to have, or tell where some article that they have lost is to be found, and who extracts money from them merely as a means of obtaining a living in this irregular way, and I believe at the bottom rather enjoying the cheat. Every now and then we hear of some brutal young farmer who has pretty nearly beaten to death a poor old woman, whom he suspected of causing a murrain among his cattle. This is what we know to exist among the least cultivated of the savage nations at the present time, and always to have existed. But we hope that the progress of rationalism in our own community will, in time, put an end to this, as it has in the middle and upper ranks of society during the last century or century and a half. It is not very long since almost every one believed in the possession of these occult powers by men and women, but especially by old women. This belief has prevailed generally in countries which have been overridden by a gloomy fanaticism in religious matters. I speak of it simply as a matter of history. There is no question at all that this prevailed where the Romish Church was most intolerant, especially in countries where the Inquisition was dominant, and its powers were exerted in such a manner as to repress free thought and the free exercise of feeling; and, again, where strong Calvinism has exercised an influence of exactly the same kind—as in Scotand, a century and a half ago, and in New England, where there was the same kind of religious fanaticism. It is in these communities that belief in witchcraft has been most rife, has extended itself most generally, and has taken possession of the public mind most strongly; and the most terrible results have happened. Now, I will only cite one particular instance, that of New England, in the early part of the last century and the end of the century before. Not very long after the settlement of New England, there was a terrible outbreak of this belief in witchcraft. It began in a family, the children of which were out of health; and certain persons whom they disliked were accused of having bewitched them. Against these persons a great deal of evidence that we should now consider most absurd was brought forward, and they were actually

executed: and some of them under torture, or under moral torture—for it was not merely physical torture that was applied; in many cases it was the distress and moral torture of being so accused, the dread, even if found not guilty, of being considered outcasts all their lives, or of being a burden to their friends—made confessions which any sober persons would have considered perfectly ridiculous; but, under the dominant idea of the reality of this witchcraft, no one interfered to point out how utterly repugnant to common-sense these confessions were, as well as the testimony that was brought forward. And this spread to such a degree in New England, one person being accused after another, that, at last, even those who considered themselves God's chosen people began to feel, "Our turn may come next;" they then began to think better of it, and so put an end to these accusations, even some who were under sentence being allowed to go free; and to the great surprise of those who were entirely convinced of the truth of these accusations, this epidemic subsided, and witchcraft was not heard of for a long time afterward; so that the belief has never prevailed in New England from that time to the present, excepting among the lowest and most ignorant class. In Scotland, these witch-persecutions attained to a most fearful extent during the seventeenth century. They were introduced into England very much by James I., who came to England possessed by these ideas, and he communicated them to others, and there were a good many witch-persecutions during his reign. After the execution of Charles I., and during the time of the Commonwealth and the Puritans, there were a good many witch-persecutions; but I think, after that, very little more was heard of them. And yet the belief in witchcraft lingered for a considerable time longer. It is said that even Dr. Johnson was accustomed to remark that he did not see that there was any proof of the non-existence of witches; that, though their existence could not be proved, he was not at all satisfied that they did not exist. John Wesley was a most devout believer in witchcraft, and said on one occasion that, if witchcraft was not to be believed, we could not believe in the Bible. So you see that this belief had a very extraordinary hold over the public mind. It was only the most intelligent class, whose minds had been freed from prejudice by general culture, who were really free from it; and that cultivation happily permeated downward, as it were; so that now I should hope there are very few among our intelligent working-class in our great towns—where the general culture is much higher than it is in the agricultural districts—who retain any thing more than the lingering superstition which is to be found even in the very highest circles—as, for instance, not liking to be married on a Friday, or not liking to sit down thirteen at the dinner-table. These are things which even those who consider themselves the very aristocracy of intellect will sometimes confess to, laughing at it all the time, but saying, "It goes against the grain, and I would rather not do it." These,

I believe, are only lingering superstitions that will probably pass away in another half century, and we shall hear nothing more of them; the fact being that the tendency to these delusions is being gradually grown out of.

Now, this is the point I would especially dwell upon. To the child-mind nothing is too strange to be believed. The young child knows nothing about the Laws of Nature; it knows no difference between what is conformable to principles, and what, on the other hand, is so strange that an educated man cannot believe it. To the child every new thing that it sees is equally strange; there is none of that power of discrimination that we acquire in the course of our education—the education given to us, and the education that we give ourselves. We gradually, in rising to adult years, grow out of this incapacity to distinguish what is strange from what is normal or ordinary. We gradually come to feel—"Well, I can readily believe that, because it fits in with my general habit of thought; I do not see any thing strange in this, although it is a little unusual." But, on the other hand, there are certain things we feel to be too strange and absurd to be believed; and that feeling we come to especially, when we have endeavored to cultivate our Common-Sense in the manner which I described to you in my last lecture. The higher our common-sense—that is, the general resultant of the whole character and discipline of our minds—the more valuable is the direct judgment that we form by the use of it. And it is the growth of that common-sense, which is the most remarkable feature in the progress of thought during the last century. The discoveries of science; the greater tendency to take rational and sober views of religion; the general habit of referring things to principles; and a number of influences which I cannot stop particularly to describe, have so operated on the public mind, that every generation is raised, I believe, not merely by its own culture, but by the acquired result of the experience of past ages; for I believe that every generation is born, I will not say wiser, but with a greater tendency to wisdom. I feel perfectly satisfied of this, that the child of an educated stock has a much greater power of acquiring knowledge than the child of an uneducated stock; that the child that is the descendant of a race in which high moral ideas have been always kept before the mind, has a much greater tendency to act uprightly than the child that has grown up from a breed that has been living in the gutter for generations past. I do not say that these activities are born with us, but the tendency to them—that is, the aptitude of mind for the acquirement of knowledge, the facility of learning, the disposition to act upon right principles—I believe is, to a very great degree, hereditary. Of course we have lamentable examples to the contrary, but I am speaking of the general average. I am old enough now to look back with some capacity of observation for forty years, and I can see in the progress of society a most marked evidence of the higher general intelligence, the

greater aptitude for looking at things as they are, and for not allowing strange, absurd notions to take possession of the mind; while, again, I can trace, even within the last ten years, in a most remarkable manner, the prevalence of a desire to do right things for the right's sake, and not merely because they are politic. And I am quite sure that there is a gradual progress in this respect, which has a most important influence in checking aberrations of the class of which I have spoken.

Still we see these aberrations, and there is one just now which is exciting a good deal of attention—that which you have heard of under the name of "Spiritualism." Now, I look upon the root of this spiritualism to lie in that which is a very natural, and in some respects a wholesome disposition of the kind—a desire to connect ourselves in thought with those whom we have loved and who are gone from us. Nothing is more admirable, more beautiful, in our nature than this longing for the continuance of intercourse with those whom we have loved on earth. It has been felt in all nations and at all times, and we all of us experience it in regard to those to whom we have been most especially attached. But this manifestation of it is one which those who experience this feeling in its greatest purity and its greatest intensity feel to be absurd and contrary to common-sense—that the spirits of their departed friends should come and rap upon tables and make chairs dance in the air, and indicate their presence in grotesque methods of this kind. The most curious part of it is that the spirits should obey the directions of the persons with whom they profess to be in communication—that when they say, "Rap once if you mean yes, and rap twice if you mean no," and so on, they should just follow any orders they receive as to the mode in which they will telegraph replies to their questions. It seems to me repugnant to one's common-sense; but the higher manifestations of these spiritual agencies seem to me far more repugnant to common-sense; and that is when persons profess to be able to set all the laws of Nature at defiance; when it is said, for instance, that a human being is lifted bodily up into the air and carried, it may be, two or three miles, and descends through the ceiling of a room. One of the recent statements of this kind, you know, is that a certain very stout and heavy lady was carried a distance of about two miles from her own house, and dropped plump down upon the table round which eleven persons were sitting; she came down through the ceiling, they could not state how, because they were sitting in the dark, and that darkness has a good deal to do with most of these manifestations. Now, let us analyze them a little. I am speaking now of what I will call the genuine phenomena—those which happen to persons who really are honest in their belief. I exclude altogether, and put aside the cases, of which I have seen numbers, in which there is the most transparent trickery, and in which the only wonder is, that any rational persons should allow themselves to be deceived by it.

I have paid a great deal of attention during the last twenty years to this subject, and I can assure you that I have, in many instances, known things most absurd in themselves, and most inconsistent with the facts of the case as seen by myself and other sober-minded witnesses, believed in by persons of very great ability, and, upon all ordinary subjects, of great discrimination. But I account for it by the previous possession of their minds by this dominant idea—the expectation they have been led to form, either by their own earnest desire for this kind of communication, or by the sort of contagious influence to which some minds are especially subject. I say "the earnest desire," for it is a very curious thing that many of those who are the most devout spiritualists are persons who have been themselves previously rather skeptical upon religious matters; and many have said to me that this communication is really the only basis of their belief in the unseen world. Such being the case, I cannot wonder that they cling to it with very strong and earnest feeling. A lady, not undistinguished in the literary world, assured me several years ago that she had been converted by this spiritualism from a state of absolute unbelief in religion; and she assured me, also, that she regarded medical men and scientific men, who endeavored to explain these phenomena upon rational principles, and to expose deception, where deception did occur, as the emissaries of Satan, who so feared that the spread of spiritualism would destroy his power upon earth, that he put it into the minds of medical and scientific men to do all that they could to prevent it. Now that, I assure you, is a fact. That was said to me by a lady of considerable literary ability, and I believe it represents, though rather extravagantly, a state of mind which is very prevalent; the great spread of the intense materialism of our age tending to weaken, and in some instances to destroy, that healthful longing which we all have, I believe, in our innermost nature, for a higher future existence, and which is to my mind one of the most important foundations of our belief in it. We live too much in the present; we think too much of the things of the world as regards our material comfort and enjoyment, instead of thinking of them as they bear upon our own higher nature. I believe that this tendency, which I think is especially noticeable in America—or at least it was a few years ago—from all that I was able to learn, had a great deal to do with the spread of this belief in what is called Spiritualism. The spiritualists assert that in America they are numbered by millions, and that there are very few people of any kind of intellectual culture who have not either openly or secretly given in their adhesion to it. I believe that is a gross exaggeration; still, there can be no doubt, from the number of periodicals they maintain, and the advertisements in them of all kinds of strange things that are done —spirit-drawings made, drawings of deceased friends, and spiritual instruction given of various kinds—that there must be a very extended belief in this notion of communication with the unseen world through these "media."

I can only assure you for myself that, having, as I have said, devoted considerable attention to this subject, I have come to the conclusion most decidedly—with, I believe I may say, as little prepossession as most persons, and with every disposition to seek for truth simply—to allow for our knowledge, or I would rather say for our ignorance, a very large margin of many things that are beyond our philosophy—with every disposition to accept facts when I could once clearly satisfy myself that they were facts—I have had to come to the conclusion that whenever I have been permitted to employ such tests as I should employ in any scientific investigation, there was either intentional deception on the part of interested persons, or else self-deception on the part of persons who were very sober-minded and rational upon all ordinary affairs of life. Of that self-deception I could give you many very curious illustrations, but the limits of our time will prevent my giving you more than one or two. On one occasion I was assured that, on the evening before, a long dining-table had risen up and stood a foot high in the air, in the house in which I was, and to which I was then admitted for the purpose of seeing some of these manifestations by persons about whose good faith there could be no doubt whatever. I was assured by them—"It was a great pity you were not here last night, for, unfortunately, our principal medium is so exhausted by the efforts she put forth last night that she cannot repeat it." But I was assured, upon the word of three or four who were present, that this table had stood a foot high in the air, and remained suspended for some time, without any hands being near it, or at any rate with nothing supporting it; the hands might be over it. But I came to find, from experiments performed in my presence, that they considered it evidence of the table rising into the air, that it pressed upward against their hands; that they did not rest upon their sense of sight; for I was looking in this instance at the feet of the table, and I saw that the table upon which the hands of the performers were placed, and which was rocking about upon its spreading feet, really never rose into the air at all. It would tilt to one side or to the other side, but one foot was always resting on the ground. And when they declared to me that this table had risen in the air, I said, "I am very sorry to have to contradict you, but I was looking at the feet of the table all the time, and you were not; and I can assert most positively that one of the feet never left the ground. Will you allow me to ask what is *your* evidence that the table rose into the air?" "Because we felt it pressing upward against our hands." I assure you that was the answer I received; their conclusion that the table rose in the air being grounded on this, that their hands being placed upon the table, they felt, or they believed, that the table was pressing upward against their hands, though I saw all the time that one foot of the table had never left the ground. Now, that is what we call a "subjective sensation;" one of those sensations which arise in our own minds under the influence of an idea. Take,

for instance, the very common case—when we sleep in a strange bed, it may be in an inn that is not very clean, and we begin to be a little suspicious of what other inhabitants there may be in that bed; and then we begin to feel a "creepy, crawly" sensation about us, which that idea will at once suggest. Now, those are subjective sensations; those sensations are produced by the mental idea. And so in this case I am perfectly satisfied that a very large number of these spiritual phenomena are simply subjective sensations; that is, that they are the result of expectation on the part of the individual. The sensations are real to them. You know that, when a man has suffered amputation of his leg, he will tell you at first that he feels his toes, that he feels his limb; and, perhaps to the end of his life, every now and then he will have this feeling of the limb moving, or of a pain in it; and yet we know perfectly well that this is simply the result of certain changes in the nerve, to which, of course, there is nothing answering in the limb that was removed. These subjective sensations, then, will be felt by the individuals as realities, and will be presented to others as realities, when, really, they are simply the creation of their own minds, that creation arising out of the expectation which they have themselves formed. These parties believed that the table would rise; and, when they felt the pressure against their hands, they fully believed that the table was rising.

Take the case of Table-turning, which occurred earlier. I dare say many of you remember that epidemic which preceded the spiritualism; in fact, the spiritualism, in some degree, arose out of table-turning. My friend the chairman (Dr. Noble) and I hunted in couples, a good many years ago, with a third friend, the late Sir John Forbes, and we went a great deal into these inquiries; and I very well remember sitting at a table with him, I suppose twenty-five years ago, waiting in solemn expectation for the turning of the table; and the table went round. This was simply the result of one of the party, who was not influenced by the philosophical skepticism that we had on the subject, having a strong belief that the phenomenon would occur; and when he had sat for some time with his hands pressed down upon the table, an involuntary muscular motion, of the kind I mentioned in my last lecture, took place, which sent the table turning. There was nothing to the Physiologist at all difficult in the understanding of this. Prof. Faraday was called upon to explain the table-turning, which many persons set down to electricity; but he was perfectly satisfied that this was a most untrue account of it, and that the explanation was (as, in fact, I had previously myself stated in a lecture at the Royal Institution) that the movements took place in obedience to ideas. Movements of this class are what I call "ideo-motor," or reflex actions of the brain; and the occurrence of these movements in obedience to the idea entertained is the explanation of all the phenomena of table-turning. Prof. Faraday constructed a very simple testing apparatus, merely two boards, one

over the other, and confined by elastic bands, but the upper board rolling readily upon a couple of pencils or small rollers; and resting on the lower board was an index, so arranged that a very small motion of this upper board would manifest itself in the movement of the index through a large arc. He went about this investigation in a thoroughly scientific spirit. He first tied together the boards so that they could not move one upon the other, the object being to test whether the mere interposition of the instrument would prevent the action. He had three or four of these indicators prepared, and he put them down on the table so fixed that they would not move. He then put the hands of the table-turners on these; and it was found, as he fully expected, that the interposition of this indicator under their hands did not at all prevent the movement of the table. The hands were resting on the indicator; and when their involuntary pressure was exerted, the friction of the hands upon the indicators, and of the indicators upon the table, carried round the table just as it had done before. Now, if there had been any thing in the construction of the instrument to prevent it, that would not have happened. Then he loosened the upper board and put the index on, so that the smallest motion of the hands upon the board would manifest itself, before it would act on the table, in the movement of the index; and it was found that when the parties looked at the index, and watched its indications, they were pulled up as it were, at the very first involuntary action of their hands, by the knowledge that they were exerting this power, and the table then never went round. One of the strangest parts of this popular delusion was, that even after this complete exposure of it by Faraday, there were a great many persons, including many who were eminently sensible and rational in all the ordinary affairs of life, who said: "Oh, but this has nothing at all to do with it. It is all very well for Prof. Faraday to talk in this manner, but it has nothing at all to do with it. We *know* that we are not exerting any pressure. His explanation does not at all apply to *our* case." But then Prof. Faraday's table-turners were equally satisfied that *they* did not move the table, until the infallible index proved that they did. And if any one of these persons, who *know* that they did not move the table, were to sit down in the same manner with those indicators, it would have been at once shown that they did move the table. Nothing was more curious than the possession of the minds of sensible men and women by this idea that the tables went round by an action quite independent of their own hands; and not only that, but that really, like the people in the dancing mania, they *must* follow the table. I have seen sober and sensible people running round with a table, and with their hands placed on it, and asserting that they could not help themselves—that they were obliged to go with the table. Now, this is just simply the same kind of possession by a dominant idea, that possessed the dancing maniacs of the middle ages.

Then the Table-tilting came up. It was found that the table would tilt in obedience to the directions of some spirit, who was in the first instance (I speak now of about twenty years ago) always believed to be an evil spirit. The table-tilting first developed itself in Bath, under the guidance of some clergymen there, who were quite satisfied that the tiltings of the table were due to the presence of evil spirits. And one of these clergymen went further, and said that it was Satan himself. But it was very curious that the answers obtained by the rappings and tiltings of the tables always followed the notions of the persons who put the questions. These clergymen always got these answers as from evil spirits, or satisfied themselves that they were evil spirits by the answers they got. But, on the other hand, other persons got answers of a very different kind; an innocent girl, for instance, asked the table if it loved her, and the table jumped up and kissed her. A gentleman who put a question to one of these tables got an extremely curious answer, which affords a very remarkable illustration of the principle I was developing to you in the last lecture—the unconscious action of the brain. He had been studying the life of Edward Young, the poet, or at least had been thinking of writing it; and the spirit of Edward Young announced himself one evening, as he was sitting with his sister-in-law—the young lady who asked the table if it loved her. Edward Young announced himself by the raps, spelling out the words in accordance with the directions that the table received. He asked, "Are you Young, the poet?" "Yes." "The author of the 'Night Thoughts?'" "Yes." "If you are, repeat a line of his poetry." And the table spelled out, according to the system of telegraphy which had been agreed upon, this line:

"Man is not formed to question, but adore."

He said, "Is this in the 'Night Thoughts?'" "No." "Where is it?" "J O B." He could not tell what this meant. He went home, bought a copy of Young's works, and found that in the volume containing Young's poems there was a poetical commentary on Job which ended with that line. He was extremely puzzled at this; but two or three weeks afterward he found he had a copy of Young's works in his own library, and was satisfied from marks on it that he had read that poem before. I have no doubt whatever that that line had remained in his mind, that is, in the lower stratum of it; that it had been entirely forgotten by him, as even the possession of Young's poems had been forgotten; but that it had been treasured up as it were in some dark corner of his memory, and had come up in this manner, expressing itself in the action of the table, just as it might have come up in a dream.

These are curious illustrations, then, of the mode in which the minds of individuals act when there is no cheating at all—this action of what we call the subjective state of the individual dominating these

movements; and I believe that that is really the clew to the interpretation of the genuine phenomena. On the other hand, there are a great many which we are assured of—for instance, this descent of a lady through the ceiling—which are self-delusions, pure mental delusions, resulting from the preconceived idea and the state of expectant attention in which these individuals are. Here are a dozen persons sitting round a table in the dark, with the anticipation of some extraordinary event happening. In another dark *séance* one young lady thought she would like to have a live lobster brought in, and presently she began to feel some uncomfortable sensations, which she attributed to the presence of this live lobster; and the fact is recorded that two live lobsters were brought in; that is, they appeared in this dark *séance*—making their presence known, I suppose, by crawling over the persons of the sitters. But that is all we know about it—that they felt something—they say they were two live lobsters, but what evidence is there of that?—the *séance* was a dark one. We are merely told that the young lady thought of a live lobster; she said they had received so many flowers and fruits that she was tired of them, and she thought of two live lobsters; and forthwith it was declared that the live lobsters were present. I certainly should be much more satisfied with the narration, if we were told that they had made a supper off these lobsters after the *séance* was ended.

Now, it has been my business lately to go rather carefully into the analysis of several of these cases, and to inquire into the mental condition of some of the individuals who have reported the most remarkable occurrences. I cannot—it would not be fair—say all I could say with regard to that mental condition; but I can only say this, that it all fits in perfectly well with the result of my previous studies upon the subject, viz., that there is nothing too strange to be believed by those who have once surrendered their judgment to the extent of accepting as credible things which common-sense tells us are entirely incredible. One gentleman says he glories in not having that scientific incredulity which should lead him to reject any thing incredible merely because it seems incredible. I can only say this, that we might as well go back to the state of childhood at once, the state in which we are utterly incapable of distinguishing the strange from the true. That is a low and imperfect condition of mental development; and all that we call education tends to produce the habit of mind that shall enable us to distinguish the true from the false—actual facts from the creations of our imagination. I do not say that we ought to reject every thing that to us, in the first instance, may seem strange. I could tell you of a number of such things in science within your own experience. How many things there are in the present day that we are perfectly familiar with—the electric telegraph, for instance—which fifty years ago would have been considered perfectly monstrous and incredible. But there we have the *rationale*. Any person who chooses

to study the facts may at once obtain the definite scientific *rationale;* and these things can all be openly produced and experimented upon, expounded and explained. There is not a single thing we are asked to believe of this kind, that cannot be publicly exhibited. For instance, in this town, last week, I saw a stream of molten iron coming out from a foundery; I did not see on this occasion—but the thing has been done over and over again—that a man has gone and held his naked hand in such a stream of molten iron, and has done it without the least injury; all that is required being, to have his hand moist, and if his hand is dry he has merely to dip it in water, and he may hold his hand for a certain time in that stream of molten iron without receiving any injury whatever. This was exhibited publicly at a meeting of the British Association at Ipswich many years ago, at the foundery of Messrs. Ransome, the well-known agricultural implement makers. It is one of the miracles of science, so to speak; they are perfectly credible to scientific men, because they know the principle upon which it happens, and that principle is familiar to you all—that if you throw a drop of water upon hot iron, the water retains its spherical form, and does not spread upon it and wet it. Vapor is brought to that condition by intense heat, that it forms a sort of film, or atmosphere, between the hand and the hot iron, and for a time that atmosphere is not too hot to be perfectly bearable. There are a number of these miracles of science, then, which we believe, however incredible at first sight they may appear, because they can all be brought to the test of experience, and can be at any time reproduced under the necessary conditions. Houdin, the conjurer, in his very interesting autobiography—a little book I would really recommend to any of you who are interested in the study of the workings of the mind, and it may be had for two shillings—Houdin tells you that he himself tried this experiment after a good deal of persuasion; and he says that the sensation of immersing his hand in this molten metal was like handling liquid velvet. These things, I say, can be exhibited openly—aboveboard; but these Spiritual phenomena will only come just when certain favorable conditions are present—conditions of this kind, that there is to be no scrutiny—no careful examination by skeptics; that there is to be every disposition to believe, and no manifestation of any incredulity, but the most ready reception of what we are told. I was asked some years ago to go into an investigation of the Davenport Brothers; but then I was told that the whole thing was to be done in the dark, and that I was to join hands and form part of a circle; and I responded to the invitation by saying that in all scientific inquiries I considered the hands and the eyes essential instruments of investigation, and that I could not enter into any inquiry, and give whatever name I possess in science to the result of it, in which I was not allowed freely to use my hands and my eyes. And, wherever I have gone to any of these Spiritual manifestations, and have been bound over not

to interfere, I have seen things which, I feel perfectly certain, I could have explained if I had only been allowed to look under the table, for instance, or to place my leg in contact with the leg of the medium. And it has been publicly stated within the last month, that the very medium whom I suspected strongly of cheating on an occasion of this kind, was detected in the very acts which I suspected, but which I was not allowed to examine. I cannot, then, go further into this inquiry at the present time, but I can only ask you to receive my assurance as that of a scientific man, who has for a long course of years been accustomed to investigate the curious class of actions to which I have alluded, and which disguise themselves under different names. A great number of the very things now done, by persons professing to call themselves Spiritualists, were done thirty years ago, or professed to be done, by those who call themselves "Mesmerists;" thus the lifting of the whole body in the air was a thing that was asserted as possible by mesmerists, as is now done by Mr. Home and his followers. These things, I say, crop up now and then, sometimes in one form, sometimes in another; and it is the same general tendency to credulity, to the abnegation of one's common-sense, that marks itself in every one of these epidemics.

Thus, then, we come back to the principle from which we started—that the great object of all education should be to give to the mind that rational direction which shall enable it to form an intelligent and definite judgment upon subjects of this kind, without having to go into any question of formal reasoning upon them. Thus, for example, is it more probable that Mr. Home floated out of one window and in at another, or that Lord Lindsay should have allowed himself to be deceived as to a matter which he admits only occurred *by moonlight?* That is the question for common-sense. I believe, as I stated just now, that the tendency to the higher culture of the present age will manifest itself in the improvement of the next generation, as well as of our own; and it is in that hope that I have been encouraged on this and other occasions to do what I could for the promotion of that desire for self-culture, of which I see so many hopeful manifestations at the present day. When once a good basis is laid by primary education, I do not see what limit there need be to—I will not say the *learning* of future generations—but to their *wisdom*, for wisdom and learning are two very different things. I have known some people of the greatest learning, who had the least amount of wisdom of any persons who have come in my way. Learning, and the use that is made of it, are two very different things. It is the effort to acquire a distinct and definite knowledge of any subject that is worth learning, which has its ultimate effect, as I have said, upon the race, as well as upon the individual.

But there are great differences, as to their effects upon the mind, among different subjects of study; and I have long been of opir

ion that those studies afford the best discipline, in which the mind is brought into contact with outward realities—a view which has lately been put forth with new force by my friend Canon Kingsley. You know that Canon Kingsley has acquired great reputation as an historian. He held the Professorship of History at the University of Cambridge for many years, and, in fact, has only recently withdrawn from it. Canon Kingsley also early acquired a considerable amount of scientific culture, and he has always been particularly fond of Natural History. Now, he lately said to the working-men of Bristol that he strongly recommended them to cultivate Science, rather than study History; having himself almost withdrawn from the study of history, for this reason, that he found it more and more difficult to satisfy himself about the truth of any past event; while, on the other hand, in the study of science, he felt that we were always approaching nearer to the truth. A few days ago I was looking through a magazine article on the old and disputed question of Mary Queen of Scots, which crops up every now and then. She is once more put upon her trial. Was Mary Queen of Scots a vicious or a virtuous woman? The question will be variously answered by her enemies and by her advocates; and I believe it will crop up to the day of doom, without ever being settled. Now, on the other hand, as we study scientific truth, we gain a certain point, and may feel satisfied we are right up to that point, though there may be something beyond; while the elevation we have gained enables us to look higher still. It is like ascending a mountain; the nearer we get to the top, the clearer and more extensive is the view. I think this is a far better discipline to the mind than that of digging down into the dark depths of the past, in the search for that which we cannot hope ever thoroughly to bring to light. It so happened that only a fortnight ago I had the opportunity of asking another of our great historians, Mr. Froude, what he thought of Canon Kingsley's remark. He said, "I entirely agree with it;" and, in some further conversation I had with him on the subject, I was very much struck with finding how thoroughly his own mind had been led, by the very important and profound researches he has made into our history, to the same conclusion—the difficulty of arriving at absolute truth upon any historical subject. Now, we do hope and believe that there is absolute truth in Science, which, if not at present in our possession, is within our reach; and that, the nearer we are able to approach to it, the clearer will be our habitual perception of the difference between the real and the unreal, the firmer will be our grasp of all the questions that rise in the ordinary course of our lives, and the sounder will be the judgment we form as to great political events and great social changes. Especially will this gain be apparent in our power of resisting the contagious influence of "Mental Epidemics."

THE PRACTICAL MAN AS AN OBSTRUCTIVE.[1]

By Mr. BRAMWELL, C. E.

IN prosperous times those engaged in manufactures are too busy earning and saving money to attend to a reorganization of their plant; in bad times they are too dispirited and too little inclined to spend the money, that in better times they have saved, in replacing old and wasteful appliances by new and economical ones, and one feels that there is a very considerable amount of seeming justification for their conduct in both instances, and that it requires a really comprehensive and large intelligence and a belief in the future, possessed by only a few out of the bulk of mankind, to cause the manufacturer to pursue that which would be the true policy, as well for his own interests as for those of the community. But there is a further and a perpetual bugbear in the way of such improvements, and that bugbear is the so-called "practical man," and he was in my mind when, in previous parts of this address, I have hinted at the existence of an obstacle to the adoption of improvement.

I do not wish the section for one moment to suppose that I, brought up as an apprentice in a workshop, and who all my life have practised my profession, intend to say one word against the truly practical man. On the contrary, he is the man of all others that I admire, and by whom I would wish persons to be guided, because the truly practical man is one who knows the reason of that which he practises, who can give an account of the faith that is in him, and who, while he possesses the readiness of mind and the dexterity which arise from long-continued and daily intercourse with the subject of his profession, possesses also that necessary amount of theoretical and scientific knowledge which would justify him in pursuing any process he adopts, which in many cases enable him to devise new processes, or which, at all events, if he be not of an inventive quality of mind, will enable him to appreciate and value the new processes devised by others. This is the truly practical man, about whom I have nothing to say except that which is most laudatory. But the practical man as commonly understood means a man who knows the practice of his trade, and knows nothing else concerning it; the man whose wisdom consists in standing by, seeing but not investigating the new discoveries which are taking place around him; in decrying those discoveries; in applying to those who invent improvements, even the very greatest, the epithet of "schemes;" and then, when he finds that beyond all dispute some new matter is good and has come into general practice, taking to it grumblingly, but still taking to it, because if he do not he could not compete with his

[1] Extract from the opening address of the chairman of the Mechanical Section of the British Association, at Brighton.

co-manufacturers, the aim and object of such a man being to insure that he should never make a mistake by embarking his capital or his time in that which has not been proved by men of large hearts and large intelligence. It is such a practical man as this who delays all improvement. For years he delayed the development in England of the utilization of the waste gases of blast-furnaces, and he has done it so successfully that, as I have already had occasion to remark, this utilization is by no means universal in this kingdom. It was such men as these who kept back surface condensation for twenty years. It is such a man as this who, when semaphores were invented, would have said, "Don't suggest such a mode to me of transmitting messages; I am a practical man, sir, and I believe that the way to transmit a message is to write it on paper, deliver it to a messenger, and put him on horseback." In the next generation his successor would be a believer in semaphores, and when the electrical telegraphist came to him and said, "Do you know that I can transmit movement by invisible electrical power through a wire, however long, and it seems to me that if one were to make a code out of this movement I could speak to you at Portsmouth at one end of the wire while I was in London at the other," what would have been the answer of the practical man? "Sir, I don't believe in transmitting messages by an invisible agency; I am a practical man, and I believe in semaphores, which I can see working." In like manner when the Siemens regenerative gas-furnace was introduced, what said the practical man? "Turn your coals into gas and burn the gas, and then talk of regeneration! I don't know what you mean by regeneration, except in a spiritual sense. I am a practical man, and if I want heat out of coals I put coals on to a fire and burn them;" and for fifteen years the practical man has been the bar to this most enormous improvement in metallurgical operations. The practical man is beginning slowly to yield with respect to these furnaces, because he finds, as I have already said, that men of greater intelligence have now in sufficiently large numbers adopted the invention to make a formidable competition with persons who stolidly refuse to be improved. The same practical man for years stood in the way of the development of Bessemer steel. Now he has been compelled to become a convert.

I will not weary you by citing more instances; but one knows, and one's experience teaches one that this is the conduct of the so-called practical man; and his conduct arises not only from the cause which I have given (his ignorance of the principles of his profession), but from another one which I have had occasion to allude to when speaking upon a different subject, and that is, you offend his pride when you come to him and say, "Adopt such a plan; it is an improvement on the process you carry on." His instinct revolts at the notion that you, a stranger, very likely his junior, and very probably, if the improvement be an original and radical one, a person not even connected with the trade to which that improvement relates, should dare to assert that

you can inform him of something connected with his business that he did not know. It may be said that employers and the heads of manufactories are, as a rule, in these days, educated gentlemen, and that therefore it is wrong to impute to them the narrow-mindedness of the practical man. I agree that in numerous instances this would be wrong; but the fact is that, in many cases—I think I may say in most cases—the head of the establishment, the moneyed man, the man who, by his commercial ability (that most necessary element in all establishments), keeps the concern going by finding lucrative orders, is not intimately acquainted with the practice of the business carried on by his firm; he relies upon some manager or foreman, who, too commonly, is not the real, but the so-called practical man. It is such men as those who simply practise that which they have seen, without knowing why they practise it. To them the title of practical man has most improperly been attributed, and it is on the advice of such men that the true heads of the firm too commonly regulate their conduct as to the management of their business, and as to the necessary changes to be made in the way of improvement.

As I have said, the practical man derides those who bring forward new inventions, and calls them schemers. No doubt, whatever they do scheme—and well it is for the country that there are men who do so—it also may be true that the majority of schemes prove abortive; but it must be recollected that the whole progress of art and manufacture has depended and will depend upon successful discoveries which, in their inception, were and will be schemes just as much as were those discoveries that have been and will be unfruitful; but the successful discoveries, because they are successful, are taken out of the category of schemes when years of untiring application on the part of the inventors have, so to speak, thrust them down the throat of the unwilling practical man. Take the instance of Mr. Bessemer, who was beset for years by difficulties of detail in his great scheme of improvement in the manufacture of steel. As long as he was so beset the practical men chorused, "He is a schemer; he is one of the schemers; it is a scheme." Supposing that these practical difficulties had beaten Mr. Bessemer, and that they had not been overcome to this day? The practical man would have derided him still as a schemer, although the theory and groundwork of his invention would have been as true under these circumstances as it now is. Fortunately for the world, and happily for him, he was able to overcome these most vexatious hindrances and make his invention that which it is. No one now dares apply the term "schemer" to Mr. Bessemer, or "scheme" to his invention, but it is as true now that he is a "schemer" and his invention a "scheme" as it would have been had he failed up to the present to conquer the minor difficulties. It is a species of profanation to suggest, but I must suggest it, for it is true, that Watt, Stephenson, Faraday, and almost every other name among the honored dead to whose

inventive genius we owe the development that has taken place within the last century in all the luxuries, the comforts, even the bare necessities of our daily existence, would, in their day, and while struggling for success, have been spoken of as schemers, even in respect of those very inventions of which we are now enjoying the fruits. But I feel I need not labor this point further at a meeting of the Mechanical Section of the British Association, an association established for the advancement of science. I know I shall be accused of decrying the practical man and of upholding the "schemers." I say most emphatically that I do not decry the practical man; I plead guilty to the charge of decrying the miscalled practical man, and I glory in my guilt, while I readily accept that which I consider the praise of upholding "schemers," and I do so for this simple reason, that, if there were no schemers, there would be no improvement. I think it becomes a scientific body like the British Association to laud the generous effort of the unsuccessful inventor, rather than to encourage the cold selfishness of the man who stands by and sees others endeavor to raise the structure of improvement without lending a hand to help, and even sneers at the builders, but, when the structure is fully raised and solidly established, claims to come in to inhabit, and, being in, probably essays, cuckoo-like, to oust the builders and to take possession for his own benefit.

DEVELOPMENT IN DRESS.

By GEORGE H. DARWIN.

THE development of dress presents a strong analogy to that of organisms, as explained by the modern theories of evolution; and in this article I propose to illustrate some of the features which they have in common. We shall see that the truth expressed by the proverb, "Natura non facit saltum," is applicable in the one case as in the other; the law of progress holds good in dress, and forms blend into one another with almost complete continuity. In both cases a form yields to a succeeding form, which is better adapted to the then surrounding conditions; thus, when it ceased to be requisite that men in active life should be ready to ride at any moment, and when riding had for some time ceased to be the ordinary method of travelling, knee-breeches and boots yielded to trousers. The "Ulster coat," now so much in vogue, is evidently largely fostered by railway-travelling, and could hardly have flourished in the last century, when men either rode or travelled in coaches, where there was no spare room for any very bulky garment.

A new invention bears a kind of analogy to a new variation in

animals; there are many such inventions, and many such variations; those that are not really beneficial die away, and those that are really good become incorporated by "natural selection," as a new item in our system. I may illustrate this by pointing out how macintosh-coats and crush-hats have become somewhat important items in our dress.

Then, again, the degree of advancement in the scale of dress may be pretty accurately estimated by the extent to which various "organs" are specialized. For example, about sixty years ago, our present evening-dress was the ordinary dress for gentlemen; top-boots, always worn by old-fashioned "John Bull" in *Punch's* cartoons, are now reserved for the hunting-field; and that the red coat was formerly only a best coat, appears from the following observations of a "Lawyer of the Middle Temple," in No. 129 of the *Spectator:* "Here (in Cornwall) we fancied ourselves in Charles II.'s reign—the people having made little variations in their dress since that time. The smartest of the country squires appear still in the Monmouth cock; and when they go a-wooing (whether they have any post in the militia or not) they put on a red coat."[1]

But besides the general adaptation of dress above referred to, there is another influence which has perhaps a still more important bearing on the development of dress, and that is fashion. The love of novelty, and the extraordinary tendency which men have to exaggerate any peculiarity, for the time being considered a mark of good station in life, or handsome in itself, give rise, I suppose, to fashion. This influence bears no distant analogy to the "sexual selection," on which so much stress has recently been laid in the "Descent of Man." Both in animals and dress, remnants of former stages of development survive to a later age, and thus preserve a tattered record of the history of their evolution.

These remnants may be observed in two different stages or forms: 1. Some parts of the dress have been fostered and exaggerated by the selection of fashion, and are then retained and crystallized, as it were, as part of our dress, notwithstanding that their use is entirely gone (e. g., the embroidered pocket-flaps in a court uniform, now sewn fast to the coat). 2. Parts originally useful have ceased to be of any service, and have been handed down in an atrophied condition.

The first class of cases have their analogue in the peacock's tail, as explained by sexual selection; and the second in the wing of the apteryx, as explained by the effects of disuse.

Of the second kind of remnant Mr. Tylor gives very good instances when he says:[2] "The ridiculous little tails of the German postilion's coat show of themselves how they came to dwindle to such absurd rudiments; but the English clergyman's bands no longer convey their

[1] *See* p. 356 of Fairholt's "Costume in England," London, 1846.

[2] "Primitive Culture," vol. i., p. 16, London, 1871.

history to the eye, and look unaccountable enough till one has seen the intermediate stages through which they came down from the more serviceable wide collars, such as Milton wears in his portraits, and which gave their name to the 'band-box' they used to be kept in." These collars are, curiously enough, worn to this day by the choristers of Jesus College, Cambridge.

According to such ideas as these, it becomes interesting to try to discover the marks of descent in our dresses, and in making this attempt many things apparently meaningless may be shown to be full of meaning.

Women's dress retains a general similarity from age to age, together with a great instability in details, and therefore does not afford so much subject for remark as does men's dress. I propose, therefore, to confine myself almost entirely to the latter, and to begin at the top of the body, and to work downward through the principal articles of clothing.

HATS.—Hats were originally made of some soft material, probably of cloth or leather, and, in order to make them fit the head, a cord was fastened round them, so as to form a sort of contraction. This is illustrated on p. 524 of Fairholt's "Costume in England," in the figure of the head of an Anglo-Saxon woman, wearing a hood bound on with a head-band; and on p. 530 are figures of several hats worn during the fourteenth century, which were bound to the head by rolls of cloth; and all the early hats seem provided with some sort of band. We may trace the remnants of this cord or band in the present hat-band. A similar survival may be observed in the strings of the Scotch-cap, and even in the mitre of the bishop.[1]

It is probable that the hat-band would long ago have disappeared had it not been made use of for the purpose of hiding the seam joining the crown to the brim. If this explanation of the retention of the hat-band is the true one, we have here a part originally of use for one purpose applied to a new one, and so changing its function; a case which has an analogy to that of the development of the swimming-bladders of fishes, used to give them lightness in the water, into the lungs of mammals and birds, used as the furnace for supporting animal heat.

The duties of the hat-band have been taken in modern hats by two running strings fastened to the lining, and these again have in their turn become obsolete, for they are now generally represented by a small piece of string, by means of which it is no longer possible to make the hat fit the head more closely.

The ancestor from which our present chimney-pot hat takes most of its characteristics is the broad-brimmed, low-crowned hat, with an immense plume falling down on to the shoulder, which was worn during the reign of Charles II.[1] At the end of the seventeenth, and during

[1] For the origin of this curious head-dress, *see* Fairholt, p. 564. [1] Ibid., p. 540.

the eighteenth century, this hat was varied by the omission of the plume, and by giving of the brim various "cocks." That these "cocks" were formerly merely temporary is shown by Hogarth's picture of Hudibras beating Sidrophel and his man Whacum, where there is a hat, the brim of which is buttoned up in front to the crown with three buttons. This would be a hat of the seventeenth century. Afterward, during the eighteenth century, the brim was bent up in two or three places, and, notwithstanding that these "cocks" became permanent, yet the hats still retained the marks of their origin in the button and strap on the right side. The cockade, I imagine, took its name from its being a badge worn on one of the "cocks."

The modern cocked-hat, apparently of such an anomalous shape, proves, on examination, to be merely a hat of the shape above referred to; it appears further that the right side was bent up at an earlier date than the left, for the hat is not symmetrical, and the "cock" on the right side forms a straight crease in the (quondam) brim, and that on the left is bent rather over the crown, thus making the right side of the hat rather straighter than the left. The hat-band here remains in the shape of two gold tassels, which are just visible within the two points of the cocked-hat.

A bishop's hat shows the transition from the three-cocked hat to our present chimney-pot; and because sixty years ago beaver-fur was the fashionable material for hats, we must now needs wear a silken imitation, which could deceive no one into thinking it fur, and which is bad to resist the effects of weather. Even in a lady's bonnet the elements of brim, crown, and hat-band, may be traced.

The "busby" of our hussars affords a curious instance of survival. It would now appear to be merely a fancy head-dress, but on inspection it proves not to be so. The hussar was originally a Hungarian soldier, and he brought his hat with him to our country. I found the clew to the meaning of the hat in a picture of a Hungarian peasant. He wore a red nightcap, something like that worn by our brewers' men, or by a Sicilian peasant, but the cap was edged with so broad a band of fur that it made in fact a low "busby." And now in our hussars the fur has grown enormously, and the bag has dwindled into a flapping ornament, which may be detached at pleasure. Lastly, in the new "busby" of the Royal Engineers the bag has vanished, although the top of the cap (which is made of cloth and not of fur) is still blue, as was the bag formerly; the top cannot, however, be seen, except from a bird's-eye point of view.

It appears that all cockades and plumes are worn on the left side of the hat, and this may, I think, be explained by the fact that a large plume, such as that worn in the time of Charles II., or that of the modern Italian Bersaglieri, would impede the free use of the sword; and this same explanation would also serve to show how it was that the right side of the hat was the first to receive a "cock." A London

servant would be little inclined to think that he wears his cockade on the left side to give his sword-arm full liberty.

Coats.—Every one must have noticed the nick in the folded collar of the coat and of the waistcoat; this is of course made to allow for the buttoning round the neck, but it is in the condition of a rudimentary organ, for the nick would probably not come into the right place, and in the waistcoat at least there are usually neither the requisite buttons nor button-holes.

"The modern gentleman's coat may be said to take its origin from the *vest*, or long outer garment, worn toward the end of the reign of Charles II." [1] This vest seems to have had no gathering at the waist, and to have been buttoned all down the front, and in shape rather like a loose bag; to facilitate riding it was furnished with a slit behind, which could be buttoned up at pleasure; the button-holes were embroidered, and, in order to secure similarity of embroidery on each side of the slit, the buttons were sewn on to a strip of lace matching the corresponding button-hole on the other side. These buttons and button-holes left their marks in the coats of a century later in the form of gold lacing on either side of the slit of the tails.

In about the year 1700, it began to be the fashion to gather in the vest or coat at the waist, and it seems that this was first done by two buttons near the hips being buttoned to loops rather nearer to the edge of the coat, and situated at about the level of the waist. Our soldiers much in the same manner now make a waist in their loose overcoats, by buttoning a short strap to two buttons, placed a considerable distance apart on the back.

This old fashion is illustrated in a figure dressed in the costume of 1696, in an old illustration of the "Tale of the Tub," and also in the figure of a dandy smelling a nosegay, in Hogarth's picture, entitled "Here Justice triumphs in his Easy-Chair," etc., as well as elsewhere. Engravings of this transition period of dress are, however, somewhat rare, and it is naturally not common to be able to get a good view of the part of the coat under the arms. This habit of gathering in the waist will, I think, explain how it was that, although the buttons and button-holes were retained down the front edges, the coat came to be worn somewhat open in front.

The coat naturally fell in a number of plaits or folds below these hip-buttons; but in most of Hogarth's pictures, although the buttons and plaits remain, yet the creases above the buttons disappear, and seams appear to run from the buttons up under the arms. It may be worth mentioning that in all such matters of detail Hogarth's accuracy is notorious, and that therefore his engravings are most valuable for the study of the dress of the period. At the end of the seventeenth, and at the beginning of the eighteenth centuries, coats seem very commonly to have been furnished with slits running from the edge of the

[1] Fairholt, p. 479.

skirt, up under the arms, and these were made to button up, in a manner similar in all respects to the slit of the tails. The sword was usually worn under the coat, and the sword-hilt came through the slit on the left side. Later on these slits appear to have been sewed up, and the buttons and button-holes died away, with the exception of two or three buttons just at the tops of the slits; thus in coats of about the year 1705, it is not uncommon to see several buttons clustered about the tops of all three slits. The buttons at the top of the centre slit entirely disappeared, but the two buttons now on the backs of our coats trace their pedigree up to those on the hips. Thus it is not improbable that, although our present buttons represent those used for making the waist, as above explained, yet that they in part represent the buttons for fastening up these side-slits.

The folds which we now wear below the buttons on the back are the descendants of the falling plaits, notwithstanding that they appear as though they were made for, and that they are in fact commonly used as, the recesses for the tail-pockets; but that this was not their original object is proved by the fact that during the last century the pockets were either vertical or horizontal, placed a little in front of the two hip-buttons (which have since moved round toward the back), and had highly-embroidered flaps, buttons, and button-holes. The horizontal pockets may now be traced in the pocket-flaps of court-dress before alluded to; and the vertical pocket is represented by some curious braiding and a row of buttons, which may be observed on the tails of the tunics of the Foot-Guards. The details of the manner in which this last rudiment became reduced to its present shape may be traced in books of uniforms, and one of the stages may now be frequently seen in the livery of servants, in the form of a row of three or four buttons running down near the edge of the tail, *sewn* on to a scalloped patch of cloth (the pocket-flap), which is itself sewed to the coat.

In the last century, when the coats had large flapping skirts, it became the custom (as may be seen in Hogarth's pictures) to button back the two corners of the coat, and also to button forward the inner corners, so as to separate the tails for convenience in riding.[1] This custom left its traces in the uniform of our soldiers down to the introduction of the modern tunic, and such traces may still be seen in some uniforms, for example, those of a lord-lieutenant and of the French gensdarmerie. In the uniforms of which I speak, the coats have swallow-tails, and these are broadly edged with a light-colored border, tapering upward and getting broader downward; at the bottom of the tail, below where the borders join (at which joining there is usually a button), there is a small triangle of the same color as the coat with its apex at this button. This curious appearance is explained thus: the two corners, one of which is buttoned forward and the

[1] It seems to have been in actual use in 1760, although not in 1794. *See* Cannon's "Hist. Rec. of British Army" (London, 1837), the Second Dragoon Guards

other backward, could not be buttoned actually to the edge of the coat, but had to be fastened a little inland as it were; and thus part of the coat was visible at the bottom of the tail: the light-colored border, although sewn to the coat, evidently now represents the lining, which was shown by the corners being turned back.

It was not until the reign of George III. that coats were cut back at the waist, as are our present evening-coats; but since, before that fashion was introduced, the coats had become swallow-tailed in the manner explained, it seems likely that this form of coat was suggested by the previous fashion. And, indeed, stages of development of a somewhat intermediate character may be observed in old engravings. In the uniforms of the last century the coats were double-breasted, but were generally worn open, with the flaps thrown back and buttoned to rows of buttons on the coat. These flaps, of course, showed the lining of the coat, and were of the same color as the tails; the button-holes were usually embroidered, and thus the whole of the front of the coat became richly laced. Toward the end of the century the coats were made tight, and were fastened together in front by hooks, but the vestiges of the flaps remained in a double line of buttons, and in the front of the coat being of a different color from that of the rest, and being richly laced. A uniform of this nature is still retained in some foreign armies. This seems also to explain the use of the term "facings" as applied to the collar and cuffs of a uniform, since, as we shall see hereafter, they would be of the same color as these flaps. It may also explain the habit of braiding the front of a coat, as is done in our hussar and other regiments.

In a "History of Male Fashions," published in the *London Chronicle* in 1762, we find that "surtouts have now four laps on each side, which are called 'dog's ears;' when these pieces are unbuttoned, they flap backward and forward, like so many supernumerary patches just tacked on at one end, and the wearer seems to have been playing at backswords till his coat was cut to pieces. . . . Very spruce *smarts* have no buttons nor holes upon the breast of these their surtouts, save what are upon the ears, and their garments only wrap over their bodies like a morning-gown." These dog's ears may now be seen in a very meaningless state on the breasts of the patrol-jackets of our officers, and this is confirmed by the fact that their jackets are not buttoned, but fastened by hooks.

In early times, when coats were of silk or velvet, and enormously expensive, it was no doubt customary to turn up the cuffs, so as not to soil the coat, and thus the custom of having the cuffs turned back came in. During the latter part of the seventeenth and during the eighteenth century, the cuffs were very widely turned back, and the sleeves consequently very short, and this led to dandies wearing large lace cuffs to their shirts.

The pictures of Hogarth and of others show that the coat-cuffs

were buttoned back to a row of buttons running round the wrist. These buttons still exist in the sleeves of a Queen's Counsel, although the cuffs are sewed back and the button-holes only exist in the form of pieces of braid. This habit explains why our soldiers now have their cuffs of different colors from that of their coats; the color of the linings was probably determined for each regiment by the colonel for the time being, since he formerly supplied the clothing; and we know that the color of the facings was by no means fixed until recently. The shape of the cuff has been recently altered in the line regiments, so that all the original meaning is gone.

In order to allow of turning back with ease, the sleeve was generally split on the outer side, and this split could be fastened together with a line of buttons and embroidered holes. In Hogarth's pictures some two or three of these buttons may be commonly seen above the reversed cuff; and notwithstanding that at first the buttons were out of sight (as they ought to be) in the reversed part of the cuff, yet after the turning back had become quite a fixed habit, and when sleeves were made tight again, it seems to have been usual to have the button for the cuff sewed on to the proper inside, that is to say, the real outside of the sleeve.

The early stage may be seen in Hogarth's picture of the "Guards marching to Finchley," and the present rudiment is excellently illustrated in the cuffs of the same regiments now. The curious buttons and gold lace on the cuffs and collars of the tunics of the Life-Guards have the like explanation, but this is hardly intelligible without reference to a book of uniforms, as for example Cannon's "History of the Second Dragoon Guards."

The collar of a coat would in ordinary weather be turned down and the lining shown; hence the collar has commonly a different color from that of the coat, and in uniforms the same color as have the cuffs, which form, with the collars, the so-called "facings." A picture of Lucien Bonaparte in Lacroix's work on Costume shows a collar so immense that were it turned up it would be as high as the top of his head. This drawing indicates that even the very broad stand-up collars worn in uniforms in the early part of this century, and of a different color from that of the coat, were merely survivals of an older form of turn-down collar. In these days, notwithstanding that the same difference in color indicates that the collar was originally turned down, yet in all uniforms it is made to stand up.

The pieces of braid or seams which run round the wrist in ordinary coats are clearly the last remains of the inversion of the cuffs.

TROUSERS.—I will merely observe that we find an intermediate stage between trousers and breeches in the pantaloon, in which the knee-buttons of the breeches have walked down to the ankle. I have seen also a German servant who wore a row of buttons running from the knee to the ankle of his trousers.

Boots.—One of the most perfect rudiments is presented by top-boots. These boots were originally meant to come above the knee; and, as may be observed in old pictures, it became customary to turn the upper part down, so that the lining was visible all round the top. The lining being of unblacked leather, formed the brown top which is now worn. The original boot-tag may be observed in the form of a mere wisp of leather sewn fast to the top, while the real acting tag is sewn to the inside of the boot. The back of the top is also fastened up, so that it could not by any ingenuity be turned up again into its original position.

Again, why do we black and polish our boots? The key is found in the French *cirage*, or blacking. We black our boots because brown leather would, with wet and use, naturally get discolored with dark patches, and thus boots to look well should be colored black. Now, shooting-boots are usually greased, and that it was formerly customary to treat ordinary boots in the same manner is shown by the following verse in the ballad of "Argentile and Curan:"

"He borrowed on the working daies
His holy russets oft,
And of the bacon's fat to make
His startops black and soft."

Startops were a kind of rustic high shoes. Fairholt in his work states that "the oldest kind of blacking for boots and shoes appears to have been a thick, viscid, oily substance." But for neat boots a cleaner substance than grease would be required, and thus wax would be thought of; and that this was the case is shown by the French word *cirer*, which means indifferently to "wax" or to "polish boots." Boots are of course polished because wax takes so good a polish. Lastly, patent-leather is an imitation of common blacking.

I have now gone through the principal articles of men's clothing, and have shown how numerous and curious are the rudiments or "survivals," as Mr. Tylor calls them; a more thorough search proves the existence of many more. For instance, the various gowns worn at the universities and elsewhere, afford examples. These gowns were, as late as the reign of Queen Elizabeth, simply upper garments,[1] but have survived into this age as mere badges. Their chief peculiarities consist in the sleeves, and it is curious that nearly all of such peculiarities point to various devices by which the wearing of the sleeves has been eluded or rendered less burdensome. Thus the plaits and buttons in a barrister's gown, and the slit in front of the sleeve of the B. A.'s gown, are for this purpose. In an M. A.'s gown the sleeves extend below the knees, but there is a hole in the side through which the arm is passed; the end of the sleeve is sewed up, but there is a kind of scallop at the lower part, which represents the narrowing for the

[1] *See* figures, pp. 254, 311, Fairholt.

wrist. A barrister's gown has a small hood sewed to the left shoulder, which would hardly go on to the head of an infant, even if it could be opened out into a hood-shape.

It is not, however, in our dress alone that these survivals exist; they are to be found in all the things of our every-day life. For instance, any one who has experienced a drive on a road so bad that leaning back in the carriage is impossible, will understand the full benefit to be derived from arm-slings such as are placed in first-class railway-carriages, and will agree that in such carriages they are mere survivals. The rounded tracery on the outsides of railway-carriages shows the remnants of the idea that a coach was the proper pattern on which to build them; and the word "guard" is derived from the man who sat behind the coach and defended the passengers and mails with his blunderbuss.

In the early trains (1838–'39) of the Birmingham Railway there were special "mail" carriages, which were made very narrow, and to hold only four in each compartment (two and two), so as to be like the coach they had just superseded.

The words *dele*, *stet*, used in correcting proof-sheets, the words *sed vide* or *s. v.*, *ubi sup.*, *ibid.*, *loc. cit.*, used in foot-notes, the sign "&," which is merely a corruption of the word *et*, the word *finis*, until recently placed at the ends of books, are all doubtless survivals from the day when all books were in Latin. The mark ∧ used in writing for interpolations appears to be the remains of an arrow pointing to the sentence to be included. The royal "broad-arrow" mark is a survival of the head of "a barbed javelin, carried by sergeants-at-arms in the king's presence as early as Richard the First's time."[1] Then, again, we probably mount horses from the left side lest our swords should impede us. The small saddle on the surcingle of a horse, the seams in the backs of cloth-bound books, and those at the backs of gloves, are rudiments—but to give a catalogue of such things would be almost endless. I have said enough, however, to show that by remembering that there is *nihil sine causa*, the observation of even common things of every-day life may be made less trivial than it might at first sight appear.

It seems a general rule that on solemn or ceremonial occasions men retain archaic forms; thus it is that court-dress is a survival of the every-day dress of the last century; that uniforms in general are richer in rudiments than common dress; that a carriage with a postilion is *de rigueur* at a wedding; and that (as mentioned by Sir John Lubbock) the priests of a savage nation, acquainted with the use of metals, still use a stone knife for their sacrifices—just as Anglican priests still prefer candles to gas.

The details given in this article, although merely curious, and perhaps insignificant in themselves, show that the study of dress from an

[1] Fairholt, p. 580.

evolutional stand-point serves as yet one further illustration of the almost infinite ramifications to which natural selection and its associated doctrines of development may be applied.—*Macmillan's Magazine.*

SUNLIGHT, SEA, AND SKY.

By WILLIAM SPOTTISWOODE, F. R. S.

THERE are many ways in which men have looked at life, the higher kind of life, that ideal which each of us forms in his own mind, to which we each hope that we are always tending. But all these various ideas may for the most part be grouped under two heads: the Ideal of Rest and the Ideal of Work. "Rest, rest!" said a brave old German worker, "shall I not have Eternity to rest in?" That represents one view. "Work, work!" said another; "must I not work now, that I may the better work in Eternal Life?" That represents the other. But, without entering upon the somewhat transcendental question of a future life, these ideas and aspirations have a meaning and reality even in the life which we now live. How do we hope to spend the leisure which old age may some day bring? Or, nearer still, when the day's work is done, and the day itself is not quite spent; or when such holiday as may befall each of us comes round, how do we hope to spend the time? Do we long for mere rest, for that

"land
In which it seemed always afternoon?"

Do we desire to sit us

"down upon the yellow sand
Between the sun and moon upon the shore,"

and sing with the lotus-eaters:

"All things have rest; why should we toil alone,
Nor steep our brows in slumber's holy balm,
Nor hearken what the inner spirit sings.
There is no joy but calm?"

Or do we rather with Ulysses say:

"How dull to pause, to make an end,
To rust unburnished, not to shine in use!
As though to breathe were life. Life piled on life
Were all too little, and of one to me
Too little remains; but every hour is saved
From that eternal silence, something more,
A bringer of new things; and vile it were
For some [few] suns to store and hoard myself,
And this gray spirit yearning in desire
To follow knowledge like a sinking star
Beyond the utmost bounds of human thought."

To which of these two ideals I myself lean has perhaps already betrayed itself; and that being so, I shall venture to consider your presence here a proof that, for this evening at least, you side with me, and that you are willing to spend an hour of your leisure in an intellectual effort to see a little deeper into those phenomena which Nature in this place and at this season displays with such profusion and splendor.

But at the outset I must warn you that we are met by a difficulty, for the surmounting of which you must rely upon yourselves rather than upon me. It is this: the phenomena to which I propose to draw your attention, although taking place nearly every day, and all day long, and in almost every direction, are veiled from our eyes; and it is only by the use of special appliances to aid our eyes that they can be made visible. It will be my business to supply these appliances, and, reproducing on such scale as may be possible within these four walls the optical processes which are going on in the sea and sky outside, to exhibit the hidden phenomena of which I am speaking. But it must be your part to transport yourselves mentally from the mechanism of the lecture-room to the operations of Nature, and by a "scientific use of the imagination" (to adopt what has now become a household word at these meetings) to connect the one with the other.

Now the main point in question is this: that light, when subjected to the very ordinary processes of reflection from smooth surfaces, such as a window, a mahogany table, or the sea itself, or when scattered to us from the deep clear sky, undergoes in many cases some very peculiar changes, the character and causes of which we have come here to investigate. The principal appliance which will be used to detect the existence of such changes, as well as to examine their nature, consists of this piece of Iceland spar, called—from the man who first constructed a compound block of the kind—a Nicol's prism, and this plate of quartz or rock crystal; both of which, as you will observe when the light passes through them, are clear, transparent, and colorless, and both of which transmit the direct light from the electric lamp with equal facility, however they may be turned round about the beam of light as an axis.

If, however, instead of allowing the beam to fall directly upon the Nicol, we first cause it to be reflected from this plate of glass, we shall find that the process of reflection has put the light into a new condition. The light is no longer indifferent to the rotation of the Nicol; in one position of the Nicol the light passes as before, but as the instrument is turned round the light gradually fades, and when it is turned through a right angle the light is extinguished. Beyond this position the light reappears, and the same changes of fading and revival are observed in the light for every right angle through which the instrument is turned.

But these phenomena are susceptible of a very beautiful modifica-

tion by the interposition of this plate of quartz between the reflecting surface and the Nicol. The changes in the light are no longer mere alterations of brightness, but exhibit a succession of colors resembling in their main features those of the rainbow or spectrum.

The peculiar condition to which light must be brought in order that these phenomena may be produced is called polarization; and, although an explanation of its nature must be reserved until later, I beg you to notice that it is effected in this instance by reflection from a plate of glass. A similar effect is produced if light be reflected from many other substances, such as the leaves of trees, particularly ivy, mahogany furniture, windows, shutters, and often roofs of houses, oil-paintings, etc., and last, but not least, the surface of water. In each of these cases the alternations of light and darkness are most strongly marked, and the colors (if a quartz plate be used) are most vivid, or, in technical language, the polarization is most complete, when the light is reflected from each substance at a particular angle. In proportion as the inclination of the light deviates from this angle the colors become fainter, until, when it deviates very greatly, all trace of polarization at last disappears. Without occupying the time necessary to shift our apparatus so as to exhibit this with the glass plate, we may alter the reflecting surface from glass to water, and, by projecting on the screen the beautiful phenomena of liquid waves, make visible the different degrees of polarization produced at the variously-inclined portions of the surfaces of those waves. A tea-tray will serve as well as any thing else to form our little sea, and a periodic tap at one corner will cause ripple enough for our present purpose. The waves now appear bright on the screen, and, although brighter in some parts than in others, they are nowhere entirely dark. But on turning round the Nicol the contrast of light and darkness becomes much stronger than before. Here and there the light is absolutely extinguished; in these parts the polarization is complete, in others incomplete in various degrees. And if the quartz plate be again introduced we have the beautiful phenomena of iris-colored rings playing over the surface of our miniature sea.

Now, that which you see here produced by our lamp and tea-tray, you may see any day under the bright sky of this southern coast. By using an apparatus such as we have here, or a simpler one which I will immediately describe, you may bring out for yourselves these phenomena of color, and thereby detect the profusion of polarization which Nature sheds around us. But, before describing it, there is one peculiar feature of all these experiments which must be noticed—namely, that the same results would be produced if we changed the positions of the lamp and the screen. The light which is now polarized by the glass or the water, and examined by the Nicol, might equally well be polarized by the Nicol and examined by the glass or the water. And, therefore, if we find that any contrivance will serve

for the one purpose, we may conclude that it will serve equally well for the other.

And now a word about that simpler apparatus. When light falls upon a transparent substance, part is reflected, part transmitted. If, therefore, the reflected part is polarized (and you have already seen that this is sometimes the case), it is not surprising that the transmitted part should be so also. And further, if the polarization by a single reflection or transmission is incomplete, it will become more and more complete by a repetition of the processes. This being so, if we take a pile of glass plates—say half a dozen, more or less, the thinner the better—and hold them obliquely before our eye at an angle of about 30° (say one-third of a right angle) to the direction in which we are looking, we shall have all that is necessary to detect the presence of polarization; and if, further, we hold a piece of talc or mica, such as is commonly used as a cover to the globes of gas-burners, beyond the pile of plates, color will be produced in the same general manner as with the quartz, although with some essential difference in detail.

Suppose that we now turn our attention from the sea to the sky, and that on a clear, bright day we sweep the heavens with our apparatus, or polariscope, as it is called, we shall find traces of polarization colors brought out in a great many directions. But if we observe more closely we shall find that the most marked effects are produced in directions at right angles to that of the sun, when, in fact, we are looking across the direction of the solar beams. Thus, if the sun were just rising in the east or setting in the west, the line of most vivid effect would lie on a circle traced over the heavens from north to south. If the sun were in the zenith, or immediately overhead, the most vivid effects would be found round the horizon; while at intermediate hours the circle would shift round at the same rate as the clock, so as always to retain its direction at right angles to that of the sun.

Now, what is it that can produce this effect—or what even produces the light from all parts of a clear sky? The firmament is not a solid sphere or canopy, as was once supposed; it is clear, pure space, with no contents, save a few miles of the atmosphere of our earth, and beyond that the impalpable fluid or ether, as it is called, which is supposed to pervade all space, and to transmit light from the further limits of the stellar universe. But, apart from this ether, which is certainly inoperative to produce the sky appearance as we see it, a very simple experiment will suffice to show that a diffusion, or, as it has been better called, a scattering of light, is due to the presence of small particles in the air. If a beam from the electric lamp, or from the sun if we had it, be allowed to pass the room, its track becomes visible, as is well known by its reflection from the motes or floating bodies, in fact by the dust in the air. But if we clear the air of dust, as I now do by burning it with a spirit-lamp placed underneath, the

beam disappears from the parts so cleared, and the space becomes dark. If, therefore, the air were absolutely pure and devoid of matter foreign to it, the azure of the sky would be no longer seen, and the heavens would appear black; the illumination of objects would be strong and glaring on the one side, and on the other their shadows would be deep, and unrelieved by the diffused light to which we are accustomed.

Now, setting aside the dust, of which we may hope that there is but little on the downs behind your town, or out to sea in front, there are always minute particles of water floating in the atmosphere. These vary in size from the great rain-drops which fall to earth on a sultry day, through the intermediate forms of mist and of fine, fleecy cloud, to the absolutely invisible minuteness of pure aqueous vapor which is present in the brightest of skies. It is these particles which scatter the solar rays, and suffuse the heavens with light. And it is a curious fact, established by Prof. Tyndall while operating with minute traces of gaseous vapors (which I can only notice in passing, because it belongs only in part to our present subject), that while coarse particles scatter rays of every color equally—in other words, scatter white light—finer particles scatter fewer rays from the red end of the spectrum, while the finest scatter only those from the blue end. And, in accordance with this law, clouds are white, clear sky is blue.

But besides this fact, viz., that light scattered laterally from fine particles is blue, the same philosopher perceived that light so scattered is polarized; and by that observation he again connected the celestial phenomena described above with laboratory experiments.

By a slight modification of his experiment, due to Prof. Stokes, I hope to make this visible to the audience. It will probably be in your recollection that when polarized light passed through a Nicol, its intensity is unaltered when the Nicol is in one position, but it is destroyed when it is in another at right angles to the first. I now pass the beam from the electric lamp through a tube of water containing a few drops of mastic dissolved in alcohol. The mixture so formed holds fine particles of mastic in a state of suspension; these scatter the light laterally, so as to be visible, I hope, to the entire audience. And if we were to examine with a Nicol this scattered light, we should find the phenomena of polarization. But, better still, we can cause the light to pass through the Nicol before being scattered, and produce the same effect, not only upon the particular part to which our eye is directed, but upon the whole body of scattered light. As the Nicol is turned, the light seen laterally begins to fade; and when the instrument has been turned through a right angle, the only parts remaining visible are those which are reflected from the larger impurities floating in the water independently of the mastic. An effect still more beautiful, and at the same time more instructive, can be produced by interposing, as was done in the case of reflection, a plate of quartz between

the Nicol and the medium which causes polarization. The whole beam is now suffused with color, the tint of which changes, as did the tints on the waves, while the Nicol is turned round. And not only so, but while the Nicol remains at rest, the tints are to be seen scattered in a regular and definite order in different directions about the sides of the beam. This may be shown by reflecting from a looking-glass a side of the beam not visible directly, and by comparing the tint seen by reflection with that seen direct. But this radial distribution of colors may also be shown in a more striking manner, by putting together two half-plates of quartz of the kinds which have the property of distributing the colors in opposite orders, and by observing the result along the line of junction. The compound plate here used is known by the name of a biquartz, and affords one of the most delicate tests of the presence of polarized light. In this case, when the Nicol is turned round, the colors of the two halves follow one another in opposite orders; and as each series is completed twice in a revolution of the Nicol, the halves of the quartz will be of the same color four times in a revolution—twice of one color and twice of its complementary.

The colors which we have here seen are those which would be observed, as before remarked, upon examining a clear sky in a position at right angles to that of the sun; and the exact tint visible will depend upon the position in which we hold the Nicol, as well as upon that of the sun. Suppose, therefore, we direct our apparatus to that part of the sky which is all day long at right angles to the sun, that is, to the region about the north-pole of the heavens (accurately to the north-pole at the vernal and autumnal equinox); then, if on the one hand we turn the Nicol round, say in a direction opposite to that of the sun's motion, the colors will change in a definite order; if, on the other, we hold it fixed, and allow the sun to move round, the colors will change in a similar manner. And thus, in the latter case, we might conclude the position of the sun, or, in other words, the time of day, by the colors so shown. This is the principle of Sir Charles Wheatstone's polar clock; one of the few practical applications which this branch of polarization has yet found. The action of such a clock may be thus roughly shown: There is now projected upon the screen a dial-plate, in which the hours are arranged in their usual order, but are crowded together into half their usual space, viz., twelve hours occupy half instead of the entire circle. The inner part of the disk is covered with a plate of selenite (mica would serve the purpose equally well), which is capable of revolving about its centre, and which, as you see, in a particular position shows color more strongly than in any other. An hour-hand is roughly drawn upon the plate. The apparatus here used is furnished with two Nicol's prisms, the hinder one of which imitates the polarizing effect of the sun, while that in front is the instrument with which we should examine the north-pole of the sky. The whole is now so arranged that when the plate shows

brightest color the hand points to XII., say noon. As the back Nicol is turned round, say as the sun begins to sink, the color fades; and when the plate is turned so as to restore the color, the hand points to I. Similarly, as the back Nicol is turned gradually farther, representing the passage of the sun westward during the afternoon, the position of the plate giving the strongest color, as indicated by the hand, corresponds to the successive hours of the dial; and when the Nicol has been turned through 90°, that is, when the sun has reached the horizon, the hand has moved from XII. to VI. In this way, as its inventor has remarked, a dial may be constructed which will work equally well in sunshine or in shade, or even when the sun itself is overcast, provided only that there be a patch of clear sky to the north.

Up to this point we have reproduced in an experimental fashion the general every-day phenomena, both celestial and terrestrial, which give rise to polarization; and we have given such general account of them as will serve to connect them together, and to show that they all belong to one system of laws affecting the nature of light. I should, however, regret, and I feel confident that you would share in that regret, if we were to leave the subject with its surface as it were merely scratched, and without any attempt to penetrate deeper into its substance. With your permission, therefore, we will devote such time as you may be still willing to grant me to a few elementary experiments in polarization, which, while certainly not less beautiful than those which you have already seen, will, perhaps, better illustrate the nature of the processes which we are now trying to investigate.

Polarized light, as indicated at the outset, is distinguished from common light by the presence of certain peculiarities not ordinarily found, and these peculiarities are to be detected only by means of special instruments. Light which has been reflected or transmitted at particular angles from various substances, light which has been scattered by small particles, is found to be in this peculiar condition. So likewise is light which has passed through this transparent piece of Iceland spar, or Nicol's prism, as it is called. Yet the light which has so passed through, and which is now projected on the screen, is to the unaided eye in no way different from the same light before its passage. Nevertheless, if we examine or analyze it by means of a second Nicol, we shall find the peculiarity of its condition revealed. For if either of the Nicols be turned gradually round (and remember that they are both transparent, colorless blocks of crystal) the light gradually fades until, when it has been turned through a right angle, the light is absolutely extinguished. On turning the Nicol farther the light revives, and afterward again fades, in such a manner that in a complete revolution the light is twice at its brightest, and twice is extinguished. Now, light is due to extremely small and rapid vibrations of a very subtle medium, which is supposed to pervade all space. The fact that vibrations (i. e., motions to and fro) in one direction can

produce waves advancing in another will be familiar to all of you who have watched the movement of a cork floating on the sea. You will have noticed that the cork has simply moved up and down, or nearly so, while the waves have passed, as it were, under it, along the surface of the water.

Now, in order to make clearer to our minds how this wave-motion is produced, I will throw the electric light upon a machine devised for the purpose. You now see a horizontal row of knobs. As the slider is pushed in, the knobs at one end begin to rise in succession until each has in turn attained its greatest elevation. Immediately after reaching its highest position it begins to descend; so that the knobs first rise and then fall in regular succession, and continue to rise and fall in the same manner so long as the motion is continued. Each of the knobs, beginning from number one, is thus successively at the highest position, while at the same moment those immediately before and behind it are at lower positions. And as the knob which is at the highest position represents what we call the crest of the wave, the crest will pass successively along all the knobs, beginning from the first. Thus the waves are transmitted along the line, while the vibrations take place across it. If the line of knobs represent the direction of a ray, their motions will represent the vibrations and waves to which the light is supposed to be due. In ordinary light these vibrations may take place in any directions perpendicular to the ray; and the effect of the crystal of which the Nicol is made, is to restrict these vibrations to a particular direction. In the arrangement now before you the first Nicol causes the vibrations to be altogether horizontal. When the second Nicol is placed similarly to the first, it will obviously have no further effect upon the light; but if it be turned through an angle, it will transmit only vibrations inclined to the horizontal at that angle; that is, only such part of the original horizontal vibrations as can be brought into the inclined direction; in other words, it will transmit only part of the light. And as the inclination is increased the part of the light transmitted will diminish, until, when the second Nicol is in a position to transmit only vertical vibrations (i. e., when it has turned through a right angle), the light will vanish. Such is an explanation of this fundamental experiment in polarization on the principle of what is called the Wave Theory of Light; and I have ventured to give it in some detail, because it is the key to all others, and forms a starting-point for any who may desire to go further in the subject; and it is a remarkable feature in this Wave Theory of Light that the results of many other experimental combinations, to some of which we will now proceed, might be predicted upon the principles already laid down.

If a plate of crystal, such as selenite, be placed between the two Nicols, and turned round in its own plane, it will be found that in certain positions at right angles to one another no effect is produced. These may be called neutral positions. In all other positions the field

is tinted with color, which is most brilliant when the plate has been turned through half a right angle from a neutral position. If one of the Nicols be turned, the selenite remaining still, the color will fade and entirely vanish when the Nicol has turned through half a right angle. After this position the complementary color will begin to appear, and will be brightest when the Nicol has completed a right angle.

The colors so produced depend upon the thickness of the plate; thus, if we take a plate of selenite merely split and not ground to a uniform thickness, we shall have a variety of tints indicating the thickness of each particular part; or we may, by a careful arrangement of suitable thicknesses, produce a colored pattern of delicacy and variety dependent only upon the skill with which the pieces have been worked.

A plate of the same crystal worked into a concave form is interesting as showing not only that the colors are dependent upon the thickness, but also that when, with an increasing or diminishing thickness of crystal, they have run through their cycle, they begin again; in other words, that the phenomenon is periodic. The field is then covered with a series of concentric rings, each of which is tinted with colors in a regular order.

In all these instances it is clear, from the experiments themselves, as well as from other experiments which form no part of our present subject, that the modifications which light undergoes are due to the internal structure of the crystals used. And it becomes a question of interest whether it be not possible, by some mechanical process, performed upon a non-crystalline substance, such as glass, so far to imitate a crystalline structure as to reproduce some of the optical results already shown. For this purpose let us take a bar of glass. On interposing it in its natural state between the Nicols when crossed, we find that no effect is produced in the dark field upon the screen. If, however, I merely press it as though with the intention of bending or breaking it, there will be at once brought about a condition of strain capable of affecting the vibrations of the ray falling upon it, to such a degree that some of them will find their way through the screen. And this result may be explained on precisely the same mechanical principles as in the case of the crystal. The effect may be heightened by placing the piece of glass in a vice, and screwing it up so as to bend or compress it to a greater degree than was possible by the hand alone. When this is done the direction and even the relative amount of torsion or compression of the different parts will be noted down as it were by the forms and hues of the figures thrown upon the screen.

The same kind of effect is shown by a piece of glass unevenly heated; but better still by glass which has been rapidly and unevenly cooled—unannealed glass, as it is called. In the pieces now before you, the outside, having become first cooled and solidified, has formed a rigid framework, to which all the interior has been obliged to con-

form. The interior parts have consequently undergone strains and pressures in different directions and in different degrees, in accordance with which each part has become the subject of a definite internal molecular arrangement; and these, by each in its own way, modifying the light which they transmit, give rise to the figures now before you.

I will conclude this series of experiments by one which, although not so beautiful or striking as those which you have already seen, is still interesting as bringing the subject home to us, and as the only application of polarization to commercial life which has yet been made. You will recollect the brilliant sequence of color shown by a quartz plate when submitted to polarized light. Well, the effects produced by that quartz plate are also produced by not only some other crystals, but, what is very remarkable, also by many of their solutions, e. g., by that of sugar. Into this tube I have put a solution of sugar; when it is placed before the lamp, polarization colors are shown on the screen, while the liquid itself remains colorless. If the solution be strengthened by the addition of more sugar, the tints vary; and, by accurate observation of the colors for different positions of the Nicol, the strength of the solution may be determined. An instrument constructed with proper means of registering these phenomena with accuracy is called a saccharometer.

These experiments may be multiplied almost indefinitely, and many a long winter evening might be spent in following polarization into other branches of science upon which it has something to say. For example, on examining a variety of vegetable and animal tissues, slices of wood, fronds of fern, scales of fish, hair, horn, mother-of-pearl, etc., with a suitable polariscope, we should find that they exhibit, internally, definite structural characters, capable of affecting the light, which they transmit in the same general way as do crystals. Or again, if we were to apply the principles established in an early part of this lecture to the conditions of sky, aspect, and time of day under which the photographer notices that he can obtain the most perfect image in his picture, we should find that they correspond with those which will furnish him with daylight in the most perfectly polarized condition.

Once more, among the many and curious phenomena which are visible during a solar eclipse, there is one which has longer than any other refused to lift its veil to the solicitations of science. I mean that halo of light, or corona as it is called, which extends beyond the dark disk of the moon, beyond those red flames of burning gas which the researches of Lockyer, of Janssen, and of others, have brought almost home to us, far away for millions of miles into distant regions of space. It was preëminently to investigate this phenomenon that the last Eclipse Expedition, furnished with funds by her Majesty's Government at the instance of this British Association, was sent out. And upon this investigation all the powers of the twin instruments of modern times, the spectroscope and the polariscope, were turned. The

spectroscope could tell us the nature of the substances to the combustion of which the light is due, and even the conditions of temperature and of pressure under which the combustion is taking place; but it could not disentangle those parts of the phenomenon which are due to direct, from those which are due to reflected or to scattered light. It was for the polariscope to tell us whether the corona is a terrestrial effect—a mere glare, in fact, from our own atmosphere—or a true solar phenomenon; and in the latter issue, whether any of it is due to direct rays from incandescent matter, or all of it to rays originating in such incandescent matter below, but scattered laterally from gases which have cooled in the upper regions surrounding the sun. This question has not even yet received a definitive answer. But the brief account given within the last few days by Mr. Lockyer, in anticipation of his more complete digest of the voluminous reports from the various branches of the Expedition, seems to justify us in the conclusion that the corona is substantially a solar phenomenon due not to direct but to reflected or scattered rays.

The principle upon which the polariscope enables us to make these refined distinctions in such far-off phenomena is, after all, very simple. If the corona were due wholly to the effect of our atmosphere on such light as reaches us during a total eclipse of the sun, the whole of that light would be similarly affected, because it comes very nearly from the same part of the heavens. In other words, its polarization would be uniform, and the corona, when examined by a Nicol and quartz, would appear of a uniform color. But if the phenomenon were wholly due to the sun and its surroundings, the light would be affected, if at all, differently in different directions drawn outward (like spokes or radii of a wheel) from the sun as a centre. In other words, its polarization would be arranged spokewise, or, to use the technical term, radially; and the corona, when examined as before, would vary in color on different sides of the sun.

I have already drawn largely, perhaps too largely, upon your patience. But it will not have been without purpose that, besides witnessing the exhibition of a few experiments, you should have seen, at least in outline, what manner of thing a scientific investigation is. Well, whatever it is (and I will not weary you with a dry statement of its processes), the foundation of it must always be laid in careful, accurate, and intelligent observation of facts. And it is a consideration which may well stir the hearts of us outsiders of science, especially on an occasion when we come face to face with some of the greatest philosophers of our time, that any one of us, by practising his eye and riveting his attention, may contribute some natural fact, some fragment of knowledge, to the common stock. And surely has not this a particular significance and importance to us, at a period when, by shortening the hours of labor, more leisure, as we may hope, will be at the command of many? It will, I take it, be our own fault if we spend that

leisure in walking through dry places seeking rest; for, to those who have the eyes to see and the spirit to discern, the world is neither dry nor barren; but rather, it is like the mountain as it appeared to the servant of the prophet when his eyes were opened, full of beauty and wonder, of mystery and power—full of hosts from all nations, striving manfully onward to promised lands of knowledge and of truth, and waging ceaseless warfare against ignorance and prejudice, and the long train of evils which are consequent upon them. And if, as the eventide of life draws on, our eye wax dim, and our step grow weary, so that we can no longer follow, we may still lay us down to rest in some unknown spot, in the full confidence that others will not be wanting to fill our places and gain fresh ground, though we may not live to see it.—*Nature.*

SMOKELESS GUNPOWDER.

IT is very often the case that one bird falls to the right barrel, and "the rest unhurt" go on their way, rejoicing no doubt at having escaped a deadly volley from the left barrel. There is, however, a reason for their having got off scot-free, well known to all sportsmen; i. e., the smoke from the first barrel obscured the birds from the sportsman's second aim, until they were out of range. Science, however, has discovered a panacea for this oft-recurring disappointment, in Schultze's wood-powder, a smokeless explosive which we wish to introduce to those of our readers who are not already conversant with its merits. Of course, every one knows our "dear, dirty old friend," Black Gunpowder; the acquaintance of which we made in early youth, turning it into a "devil" to frighten our grandmother; but we have cut our "dear, dirty old friend," and our gun is now loaded with Schultze's wood-powder instead. "How is this?" you inquire. "Why abandon an explosive with which Colonel Hawker, and the never-to-be-forgotten Maxwell of 'Wild Sports of the West' celebrity, killed so many head of game?" To this we reply, Schultze's wood-powder was not invented in *their* day, or they *would* have used it, and for these reasons:

For seven hundred years and more, even granting the invention to have been Roger Bacon's, the dull-black mixture of sulphur, nitre, and charcoal—it is only a mixture, not a chemical compound—has had the monopoly of guns, large and small. It has answered every purpose moderately well, perhaps more than moderately. Nevertheless, from time to time the desire has arisen to evolve out of chemical stores some new compound, mechanical or chemical, that should do better duty. Somewhat extraordinary, indeed, the case seems that, amid all the improvements of guns and gunnery, all the advancement of chemistry

and mechanism, the gaseous motor for gun-projectiles should be composed as at first. The explanation is difficult. Gunpowder occupies a sort of half-way ground between things innocent and things dangerous; a medium quality favoring its many applications. Exploding readily enough for all convenient needs, it never *spontaneously* explodes—a great point in its favor. Then its power of water-absorption not being very great, it stores tolerably well. But, more than any thing else, gunpowder has held its long and almost exclusive sway over guns and gunners owing to the two following circumstances: it can be made of any desired percentage composition, and it may be corned or grained to any degree of coarseness or fineness. As employed for different purposes, it is necessary that gunpowder should have various strengths. To a considerable extent the strength of gunpowder, by varying the relative amount of its components, can be modified; but the great adjustive resource consists in increasing or lessening the dimension of its grains.

Having taken account of certain special good qualities of gunpowder, we now come to certain of its bad qualities. Safe it indeed is in the sense of not igniting spontaneously; but it deteriorates by keeping, the more especially if in a moist atmosphere. If gunpowder be thoroughly wetted, then may it be considered wholly spoilt. In burning, gunpowder evolves much heat, much smoke; it also deposits much foulness. On the debtor side of gunpowder must be reckoned, also, the danger attendant on manufacture. It would be a great advantage if possible to devise a gunpowder that should acquire its usefully-dangerous qualities with the very last manufacturing touch, whereby in every incipient stage it might be stored without possibility of risk.

It will have been gathered, then, that gunpowder, ordinary black gunpowder, though it has seen some service and done some hard duty in its time, is not so perfect as to fulfil all requisitions desired; wherefore from time to time experiments have been directed to the manufacture of a substitute.

The only substitute yet invented which has met with favorable notice from practical sportsmen is Schultze's wood-powder, which, from its being granulated, and consequently permeated by air, can never generate fire of itself. This explosive, invented by Captain Schultze, a Prussian officer, was originally manufactured at Potsdam, near Berlin, and the factory catching fire in 1868, instead of *exploding*—ruining the neighborhood, and leaving many widows and orphans, like the recent gun-cotton explosion at Stowmarket—*burned quietly to the ground.* A company of English gentlemen, fond of field-sports, foreseeing the advantages to be derived from its introduction into England, purchased a site for its production in the New Forest, and thither we must carry our readers on "a visit to the Schultze Gunpowder manufactory," at Redbridge near Southampton.

Here and there, at intervals wide apart, are various buildings of

light structure, from one of which rises a tall chimney, instrumental in raising steam to drive a 10-horse-power sawing-machine, which rapidly creates the "wood-powder" to be turned into use for the gun by the following process:

The grains, being collected in a mass, are subjected to a treatment of chemical washing, whereby calcareous and various other impurities are separated, leaving hardly any thing behind save pure woody matter, cellulose or lignine. The next operation has for its end the conversion of these cellulose grains into a sort of incipient xyloidine, or gun-cotton material, by digestion with a mixture of sulphuric and nitric acids. Practically it is found that absolutely perfected xyloidine (of which ordinary gun-cotton is the purest type) not only decomposes spontaneously by time, the chief products of combustion being gum and oxalic acid, but it is, moreover, liable to combustion of a sort that may be practically called spontaneous, so slight and so uncontrollable are the causes sufficing to bring it about. Cellulose or woody matter, otherwise termed lignine, partially converted to xyloidine is, the inventor affirms, subject to neither of those contingencies. Our readers will understand that, inasmuch as the wood used as a constituent of the Schultze gunpowder is not charred, its original hydrogen is left, and by-and-by, at the time of firing, will be necessarily utilized toward the gaseous propulsive resultant. Next, washed with carbonate-of-soda solution and dried, an important circumstance is now recognizable.

The grains, brought to the condition just described, are stored away in bulk, not necessarily to be endowed with final explosive energy until the time of package, transport, and consignment. Only one treatment has to be carried out, and it is very simple. The ligneous grains have to be charged with a certain definite percentage of some nitrate, which is done by steeping them in the nitrate solution and drying. Ordinarily a solution of nitrate of potash (common saltpetre) is employed; but, in elaborating certain varieties of white powder, nitrate of baryta is preferred.

Having traced the new powder to its final stage, we may contemplate it under the light of two distinct scrutinies—theoretical and practical. Review of the chemical agencies involved, or that may be evolved, suggests the reaction, especially under prolonged moisture, of the sulphur and nitre of ordinary powder, whereby sulphide of potassium should result. Practice is confirmatory: under the condition indicated sulphide of potassium, more or less, does result, and proportionate to the extent of decomposition is the powder deteriorated. Inasmuch as the Schultze gunpowder is wholly devoid of sulphur, so is the particular decomposition adverted to impossible; and theory, at least, fails to suggest any other decomposition as probable or even possible.

All the buildings requisite for manufacturing this explosive are cheap

and flimsy, so that if it did catch fire no loss would ensue. The "plant of machinery" is of small cost in comparison with that used for making black gunpowder, and Schultze's wood-powder is sold at a price commensurate with its cheap production. An explosive is often "better known than liked," such as gun-cotton; but Schultze's wood-powder requires only "to be known to be liked," as a trial of it, lately made for the satisfaction of its readers by the conductors of the *Land and Water* journal, recently showed. Indeed, it was proved to give more penetration than gunpowder, and it costs less. There is also no smoke, and consequently the second barrel can always be used at once, instead of waiting for the smoke to clear away, as when using black powder.—*Belgravia.*

ON THE FUNCTIONS OF THE BRAIN.

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TRANSLATED FROM THE REVUE DES DEUX MONDES, BY A. R. MACDONOUGH, ESQ.

I.

THE first task of physiology was to localize the functions of life in the various organs of the body which serve as their instruments. Thus digestion was assigned to the stomach, circulation to the heart, respiration to the lungs; thus, too, the seat of intelligence and thought was placed in the brain. Still, with regard to the latter organ, a reservation was thought proper, excluding the idea that the metaphysical expression of the intellectual and moral powers was the manifestation, simply and merely, of the cerebral function. Descartes, who is to be classed among the promoters of modern physiology, because he thoroughly understood that the explanation of vital phenomena must depend on the general laws of physics and of mechanism, expressed himself very plainly on this matter. Adopting Galen's ideas on the formation of "animal spirits" in the brain, he assigns them the task of distribution by means of the nerves throughout the animated machine, so as to carry to each of the parts the impulse needed for its special activity. Yet, above and apart from this physiological function of the brain, Descartes admits the soul, which gives man the faculty of thinking: it was supposed to have its seat in the pineal gland, and to direct those "animal spirits" which issue from and are subject to it.

Descartes's opinions as to the function of the brain would not bear the slightest examination by modern physiology; his explanations, founded on imperfect anatomical knowledge, produced nothing but hypotheses marked by the coarsest mechanical conceptions. Yet they

have an historic value for us, in the proof that this great philosopher recognized two things in the brain: first, a physiological mechanism; and then, above and beyond that, the thinking faculty of the soul. These ideas are nearly the same with those that afterward prevailed among many philosophers and some naturalists; the brain, in which the most important functions of the nervous system are performed, was for them not the real organ of thought, but simply the substratum of intelligence. Indeed, the objection was often enough expressed, that the brain forms a physiological exception to all the other organs of the body, in that it is the seat of metaphysical manifestations, which the physiologist has no concern with. It was perceived how digestion, respiration, movement, etc., could be referred to the phenomena of mechanism, of physics, and chemistry; but it was not allowed that thought, intelligence, and will, could be subjected to like explanation. There is, it was said, a chasm between the organ and the function, because the question is about metaphysical phenomena, and not at all about physico-chemical mechanism. De Blainville, in his lectures on zoology, laid great stress on the distinction between the *organ* and the *substratum*. "In the organ," he said, "there is a visible and necessary connection between anatomical structure and function; in the heart, the organ of circulation, the form and arrangement of valves and orifices account perfectly for the circulation of the blood. In the substratum, nothing like this is observable; the brain is the substratum of thought; thought has its seat in the brain, but it cannot be inferred from the brain's anatomy." Such considerations served as a foundation for the belief that, in cases of insanity, the reason might be affected essentially, as it was termed; that is, without the existence of any lesion in the substance of the brain. Even the converse was asserted, and cases are cited in physiological treatises of the unimpaired manifestation of intelligence in persons with softened or indurated brains. The progress of modern science has destroyed all such doctrines; yet it must be admitted that those physiologists who have drawn from the most delicate recent researches into the structure of the brain the conclusion that thought must be localized in a particular substance, or in nerve-cells of a determinate form and order, have equally failed to solve the problem, since they have done nothing more, in reality, than to oppose materialistic theories to other spiritualistic theories.

From what has been said, I shall draw the only conclusion which legitimately results; namely, that the mechanism of thought is unknown to us—a conclusion with which every one will probably agree. None the less the fundamental question I have suggested exists; for what concerns us is to know whether our present ignorance on this subject is a relative ignorance which will vanish with the progress of science, or an absolute ignorance in the sense of its relating to a vital problem which must forever remain beyond the ken of physiology. For myself, I reject the latter opinion, because I deny that scientific truth can thus

be divided into fractions. How, indeed, can one understand that it is permitted to the physiologist to succeed in explaining the phenomena that occur in all the organs of the body, except a part of those that occur in the brain? Such distinctions cannot exist among vital phenomena. Unquestionably they present very different degrees of complexity, but they are all alike in being either soluble or insoluble by our examination; and the brain, marvellous as those metaphysical manifestations that take place in it appear to us, cannot form an exception among the other bodily organs.

II.

From a physiological point of view, those metaphysical phenomena of thought, consciousness, and intelligence, which serve for the various manifestations of the human soul, are nothing but ordinary vital phenomena, and can result from nothing but the action of the organ that expresses them. We shall show that, in fact, the physiology of the brain, like that of all the other bodily organs, is deduced from anatomical observations, from experiments conducted physiologically, and from the teachings of pathological anatomy.

In its anatomical development the brain follows the general law; that is, it increases in volume whenever the functions which it controls increase in energy. In the graduated orders of animals we find the brain gain in development in proportion to the greater manifestation of intelligence; and in man, with whom the phenomena of mind have reached their highest expression, the cerebral organ presents the largest volume. The intelligence of the various animals can be readily inferred from the shape of the brain, and the number of creases or folds that extend its surface. But not only does the outward appearance of the brain change with the modification of its functions; it presents in its inner structure also a complexity that increases with the variety and intensity of the mental manifestations. As regards the texture of the brain, we are long past the days of Buffon, who considered the brains, as he contemptuously called them, a mucous substance of no importance. The advance of general anatomy and of histology has taught us that the cerebral organ possesses a texture more delicate as well as more complex than that of any other nerve-arrangement. The anatomical elements that make it up are nerve-elements in the shape of tubes and of cells variously joined and interlaced. These elements are alike in all animals as to their physiological properties and histologic character; they differ as to their number, net-work, and connection, in a word their arrangement, which in the brain of various species presents a disposition peculiar to each. In this the brain again follows a general law, for in all organs the anatomical element has fixed characteristics by which it may be known; the completeness of the organ consists chiefly in the arrangement of these elements, which presents in every animal species its own peculiar

form. Every organ is in fact, then, an instrument whose constituent elements remain identical, while their grouping grows more and more involved in the same degree as the function itself displays more variety and complexity.

Reflecting, now, on the organic and physico-chemical conditions required for the support of life and the discharge of its functions, we find that they are the same in the brain as in all the other organs. The blood acts on the anatomical elements of all the tissues by supplying their indispensable conditions of nutrition, temperature, and humidity. When a diminished supply of blood flows to any organ, its activity of function declines, and the organ rests; but if the blood is quite cut off, the elementary properties of the tissue slowly change, while at the same time its function perishes. It is precisely the same as to the brain's anatomical elements: as soon as the blood ceases to flow to it, its nerve-properties are affected, as well as its function, which gradually disappears, if the blood remains wholly withheld. A simple modification of the temperature of the blood, in its pressure, is enough to produce grave disturbances in the sensibility, the power of motion, or the will.

All the bodily organs present alternate states of rest and of activity in which the phenomena of circulation differ essentially. Numerous observations, made upon the most different structures, place these facts beyond doubt. When, for instance, we examine the alimentary canal of a fasting animal, we find the mucous membrane that lines the inner face of the stomach and intestines, pale and but little supplied with blood; during digestion, on the contrary, we learn that the same membrane is highly colored, and swollen with the blood which flows energetically into it. These two phases of circulation, in a state of rest and a state of activity, have been brought under direct investigation in the stomach of a living man. All physiologists recollect the story of a young Canadian accidentally wounded by a leaden musket-ball which struck him almost point-blank on the left side. The abdominal cavity was laid open by an immense contused wound, and the stomach, extensively perforated, allowed the food which he had last taken, to escape. The patient was attended by Dr. Beaumont, a surgeon of the United States Army; he recovered, but retained a fistulous wound, opening with a circumference of about an inch and a half through which different substances could be introduced, and the action of the stomach easily examined. Dr. Beaumont, anxious to study this remarkable case, employed the young man as a servant, after the complete restoration of his health and particularly of his digestive powers. He was able to keep him in his service for seven years, during which he made a great number of observations of the highest interest to physiology. On looking into the interior of the stomach while empty of food, the lining membrane could be plainly seen, lying in uneven folds, with its surface of a pale rose-color, motionless, and lubricated by noth-

ing whatever but mucus. As soon as articles of food made their way into the stomach, and touched the mucous membrane, its circulation grew rapid and its color lively, while peristaltic movements became evident. The mucous papillæ then poured out their gastric juice, a clear and transparent fluid, designed to dissolve the food. On wiping away the mucus that covered the villous membrane, with a sponge or fine cloth, the gastric juice was soon seen reappearing and gathering in little drops that ran along the walls of the stomach like perspiration on the face. What we have just seen as to the mucous membrane is known to occur alike throughout the intestine, and in all the glandular organs connected with the digestive apparatus. The salivary glands and the pancreas, in the intervals of the act of digestion, present a pale and bloodless tissue, the secretions of which are wholly suspended. During the period of digestion, on the contrary, these same glands are swollen with blood, as if inflamed and erectile, while their vessels pour out the secreted fluids abundantly.

Two orders of circulation, then, must be recognized in the organs: one, the general circulation, known since Harvey's day; and the other, local circulation, only discovered and studied in recent times. In the phenomena of general circulation the blood may be said to do nothing more than traverse the parts, to pass from the arteries into the veins; in the phenomena of local, which is the true functional circulation, the blood penetrates all the folds of the organ, and gathers closely about its anatomical elements, to arouse and excite their special mode of activity. The nervous system, sensitive in its action through the vessels, governs all those phenomena of local circulation which attend organic activity; thus, the saliva flows copiously when a sapid substance makes an impression on the nerves of the mucous membrane of the mouth, and the gastric juice forms under the influence of contract between food and the sensitive surface of the stomach. But, for this mechanical excitement of the peripheral nerves of sensation, influencing the organ by reflex action, a purely psychic or cerebral excitement can be substituted. A simple experiment proves this: If a horse is taken while fasting, and the excretory duct of the parotid gland upon the side of the jaw is exposed and divided, nothing flows from it; the gland is at rest. If, now, oats are shown to the animal, or, still better, if, without any thing being shown, a movement is made which leads him to think he is about to have food given him, immediately a continuous flow of saliva issues from the duct of the parotid, and at the same time the tissue of the gland is injected, and becomes the seat of a more active circulation. Dr. Beaumont remarked similar phenomena in his Canadian. The idea of savory food not only solicited a secretion from the salivary glands, but provoked, besides, an immediate flow of blood to the mucous membrane of the stomach.

What we have just said as to the local or functional circulations, applies not only to those secreting organs in which there takes place

the separation of a liquid, to the formation of which the blood must more or less give its aid; it rather expresses a phenomenon generally remarked in all the organs, whatever the nature of their function may be. The muscular system, which produces nothing but mechanical work, is in this regard like the glands, which act chemically. At the instant of muscular action the blood circulates with greater activity, which relaxes when the organ begins to rest. The peripheral nervous system, the spinal marrow, and the brain, which serve to manifest the phenomena of innervation and intelligence, are equally subject to this law, as we are about to see.

The relations existing between the phenomena of circulation in the brain and the functional activity of that organ have long remained obscure, owing to mistaken ideas of the conditions of sleep, which is rightly considered the state of rest of the cerebral organ. The ancients supposed that sleep resulted from compression exerted on the brain by the blood when its circulation declined. They imagined that this pressure was chiefly exerted at the back part of the head, at the point where the veined folds of the dura mater unite in a common confluent, which is still called the *torcular or compress of Herophilus*, from the name of the anatomist who first described it. These conjectural explanations have been handed down to us; and it is only of late years that experiment has succeeded in proving their falsity. In fact, it has been shown by direct experiment that, during sleep, the brain, instead of being congested, is on the contrary pale and bloodless; while in a state of wakefulness the circulation, becoming more active, provokes a flow of blood proportioned to the intensity of cerebral activity. In this respect natural sleep and the anæsthetic sleep of chloroform are alike; in both cases, the brain, sunk into rest or inactivity, presents the same paleness and relative bloodlessness.

The experiment is made in this manner: A part of the bony covering of an animal's skull is carefully removed, and the brain laid bare so as to study the circulation at the surface of this organ. Then chloroform is administered to produce insensibility. In the first exciting stage of the action of the chloroform, the brain is observed to grow congested and to lap over at the edges; but as soon as the stage of anæsthetic sleep is reached, the substance of the brain sinks in and grows paler, presenting a languid movement of capillary circulation, which lasts as long as the state of sleep or cerebral rest continues. For the study of the brain in natural sleep a circular trepan is made on a dog's head, and the piece of bone removed is replaced by a watch-glass carefully adjusted to the exact opening, so as to prevent the irritating action of the air. The animals subjected to the operation survive it; and observations on their brain through this sort of window, while awake and when asleep, prove that when the dog is asleep the brain is always paler, and that a fresh afflux of blood is regularly noticed on his awaking, when the functions of the brain resume their activity.

Facts analogous to those observed in animals have been studied directly in the human brain. Upon a person injured by a frightful railroad accident the effect of a considerable loss of brain-substance was examined. The brain was visible over a surface of three by six inches. The patient suffered frequent and severe attacks of epilepsy and coma, during which the brain invariably expanded. Sleep succeeded these attacks, and the cerebral hernia gradually subsided. When the patient awoke, the brain again projected and rose to the level of the surface of the external, bony table. In the case of another person injured in consequence of a fracture of the skull, the cerebral circulation was studied during the administration of anæsthetics. With the first inhalations, the surface of the brain became branchy and filled with blood; the flow of blood and throbbing of the brain increased, and then, at the instant of sleep, its surface subsided by degrees below the opening, while at the same time growing relatively pale and bloodless.

Briefly, then, the brain is governed by the common law that controls blood-circulation in all the organs. By virtue of this law, when the organs are at rest and their action suspended, the circulation in them grows languid; and it increases, on the contrary, as soon as activity is resumed. The brain, I repeat, is no exception to this general law, as had been supposed, for it is now demonstrated that the state of sleep coincides not with congestion, but, on the contrary, with bloodlessness of the brain.

If we seek now to understand the relations that may exist between great activity of blood-circulation and the functional condition of the organs, we shall readily see that this increased flow of the sanguineous fluid corresponds with greater intensity in the chemical alterations going on within the tissues, as also with an exaltation in the phenomena connected with heat which are their necessary and immediate consequence. The production of heat in living beings is a fact established from remote antiquity; but the ancients had erroneous ideas as to the origin of heat: they attributed it to an innate organic power that had its seat in the heart, that ardent centre of ebullition for the blood and the passions. At a later date the lungs were regarded as a sort of furnace to which the mass of the blood repaired successively to gain the heat which circulation was bidden to distribute throughout the body. The advance of modern physiology has proved that all these absolute consignments of vital conditions to special points are chimeras. The sources of animal warmth exist everywhere, and in no region exclusively. It is only through the harmonious functional play of the various organs that the temperature is kept nearly constant in man and the warm-blooded animals. There are, in truth, as many heat-producing centres as there are special organs and tissues, and we are obliged always to connect evolving heat with functional labor of the organs. When a muscle contracts, when a mucous surface or a gland

secretes, production of heat invariably takes place at the same time with increased activity in the phenomena of local circulation.

Is the case the same with the nervous system and the brain? Modern experiments forbid us to doubt it. Whenever the spinal marrow and the nerves exhibit sensibility or movement, whenever an intellectual effort takes place in the brain, a corresponding quantity of heat is evolved in it. We must, then, regard heat in the animal economy as a resultant of the organic labor of all the parts of the body; but at the same time it becomes also the principle of activity for each of these parts. This correlation is, above all, indispensable for the brain and the nervous system, which hold all the other vital actions under their control. Experiments have demonstrated that the tissue of the brain exhibits a higher temperature than any other organ of the body. In man and the warm-blooded animals the brain itself produces the heat required for the manifestation of the peculiarities of its tissue. If this were not so, it would infallibly grow cooler, and we should at once see all the functions of the brain become torpid, and intelligence and will perish. This does, in fact, occur in cold-blooded animals, in which the function of heat-production is not energetic enough to sustain the organism in resistance to external causes of refrigeration.

III.

With respect to the organic or physico-chemical conditions of its activity, the brain, then, presents nothing exceptional. If we turn to experiments made upon it by physiologists, we shall find that they have succeeded in analyzing cerebral phenomena in the same way as those of all the other organs. The experimental process usually employed to determine the functions of organs consists in removing them or in destroying them either gradually or suddenly, so as to determine the uses of the organ according to the special disturbances thus caused in vital phenomena. This method of the removal or destruction of organs, which forms a sort of brutal vivisection, has been applied on a great scale to the study of the whole nervous system. Thus, after a nerve is cut, when the parts to which it had been distributed lose their sensibility, we conclude from this that it is one of the nerves of sensation; if it is motion that ceases, we infer thence that we are dealing with one of the nerves of motion. The same method has been applied in examining the functions of the different parts of the encephalic organ, and, though the complexity of the parts has occasioned novel difficulties of execution, the method has yielded results that are not to be contested. Every one has long known that, without the brain, intelligence is not possible, but experiment has discovered exactly the part that is played by each portion of the organ. It teaches us that consciousness, or intelligence properly so called, resides in the cerebral lobes, while the lower portions of the brain contain nervous centres destined

for organic functions of a lower kind. This is not the place to describe the special functions of these different sorts of nervous centres which are superposed and in a manner ranged along quite into the spinal marrow; it is enough to say that we owe the knowledge of them to that method of vivisection by organic removal which is adopted in a general way in all physiological inquiries. Here the brain behaves in exactly the same way as all the other bodily organs, in this sense, that every lesion of its substance produces characteristic disturbances in its functions, which always correspond with the mutilation effected.

By means of the cerebral lesions he produces, the physiologist does not stop at the creation of local paralysis, which suspends the action of the will on certain organic instruments; he is able also, by merely disturbing the equilibrium of cerebral action, to produce a suspension of freedom in voluntary motion. Thus, by injuring the peduncles of the cerebellum, and different points of the brain, the experimenter can make an animal move as he chooses, to right or left, forward or backward, or can make it turn, sometimes by leaps, sometimes by rotary movement on the axis of its body. The will of the animal persists, but power to guide its motions is gone. In spite of its efforts of will, it moves necessarily in the direction determined by the organic lesion. Pathologists have remarked numerous similar instances in man. Lesions of the peduncles of the cerebellum create rotary movements in men as in animals. Some patients could walk only straight onward. In one case, cruel in its irony, a brave veteran general could only move backward. Therefore the will, which proceeds from the brain, does not take effect on our organs of locomotion themselves; it impresses itself on secondary nervous centres, which need to be kept harmoniously balanced by a perfect physiological equilibrium.

There is another and more delicate experimental method, which consists in introducing into the blood various poisonous substances intended to exert their action upon the anatomical elements of the organs, while these are left undisturbed and kept uninjured. Aided by this method, we can extinguish separately the properties of certain nervous and cerebral elements, in the same way that we can also sever the other organic elements, whether muscular or sanguine. Anæsthetics, for instance, destroy consciousness and depress sensibility, while they leave the power of movement untouched. Curare, on the other hand, destroys the power of movement, and leaves sensibility and will unimpaired; poisons affecting the heart, suspend muscular contractility, and the oxide of carbon destroys the oxidizing properties of the blood-globules, without at all affecting the properties of the nerve-elements. As we see, by this method of investigation or elementary analysis of organic properties, the brain and those phenomena that have their seat in it may also be affected in the same manner as all the other functional instruments of the body.

There is yet a third method of experimenting, which may be called

that of experiment by reproduction. This method, to some extent, combines physiological analysis and synthesis, and enables us to establish by evidence and counter-evidence those relations which unite the organ with the function in cerebral manifestations. When the brain of the inferior animals is removed, the function of the organ is necessarily suppressed; but the persistence of life in these beings allows the brain to grow again, and, in proportion as the organ reproduces itself, we observe its functions reappear. The like experiment succeeds in the same way with superior animals, such as birds, in whom intelligence is much more developed. For instance, when the cerebral lobes of a pigeon have been removed, the animal at once loses its senses, and the power of seeking its food. Yet if the animal is artificially fed, it can survive, because its functions of nutrition continue unimpaired so long as their special nervous centres are left unharmed. Little by little the brain renews itself with its particular anatomical elements, and in the degree in which this restoration takes place we observe the animal's use of its senses, and its instincts and intelligence return. Here, I repeat with emphasis, the experiment is complete: there has been as it were both analysis and synthesis of the vital function, because the successive destruction of the different parts of the brain has successively extinguished its different functional manifestations, and because the successive reproduction of the same parts has caused the same manifestations to reappear. It is hardly necessary to add that the same thing happens as to all the other parts of the body which are susceptible of reproduction.

Diseases, which are at bottom nothing but vital perturbations caused by Nature instead of being produced by the hand of the physiologist, affect the brain according to the usual laws of pathology; that is to say, by occasioning functional troubles which always correspond to the nature and seat of the injury. In a word, the brain has its pathological anatomy exactly as all the organs of the economy have, and the pathology of the brain has its special series of symptoms, just as the other organs have theirs. In mental alienation we observe the most remarkable disturbances of the reason, furnishing in their study a rich mine for the researches of the physiologist and the philosopher; but the various forms of lunacy or madness are nothing more than disturbances of the normal function of the brain, and these alterations of function in the cerebral organ, as in all the rest, are combined with invariable anatomical alterations. If, under many circumstances, these are not yet understood, the blame must be laid wholly on the imperfection of our means of investigation. Besides, do we not find that certain poisons, such as opium and curare, paralyze the nerves and the brain, without being able to discover any visible alteration in the nerve-substance? Yet we are sure that such alterations exist; for, to admit the contrary, would be to admit an effect without a cause. When the poison has ceased to act, we find the mental disturbances disappear, and

the normal condition return. It is the same when pathological injuries are healed; the trouble in the intelligence ceases, and reason comes back. Pathology here, too, furnishes us with a kind of functional analysis and synthesis, just as may be observed in experiments of reproduction. Disease, in a word, suppresses the function more or less entirely, by changing more or less completely the texture of the organ, and the cure restores the function by reëstablishing the normal organic condition.

If the manifestations of the brain's functions were the earliest to attract the attention of philosophers, they will assuredly be the last to receive explanation from physiologists. We believe that the progress of modern science allows us now to approach the subject of the physiology of the brain; but, before beginning the study of the cerebral functions, we must clearly understand our point of departure. In this essay, we have attempted to state only one term of the problem, and to show how untenable is the opinion that the brain forms an exception in the organism, and is the *substratum* of intelligence instead of being its instrument. This idea is not merely an obsolete conception, but an unscientific one, injurious to the progress of physiology and psychology. Indeed, what sense is there in the notion that any apparatus of Nature, whether in its lifeless or its living domain, can be the seat of a phenomenon without being its instrument? Preconceived ideas clearly have a great influence in discussing the functions of the brain, and a solution is combated by arguments used for the sake of their tendency. Some refuse to allow that the brain can be the organ of intelligence, from fear of being involved by that admission in materialistic doctrines; while others eagerly and arbitrarily lodge intelligence in a round or fusiform nerve-cell, for fear of being charged with spiritualism. For ourselves, we are not concerned about such fears. Physiology tells us that, except in the difference and the greater complexity of the phenomena, the brain is the organ of intelligence in exactly the same way that the heart is the organ of circulation, and the larynx that of the voice. We discover everywhere a necessary bond between the organs and their functions; it is a general principle, from which no organ of the body can escape. Physiology should copy the example of more advanced sciences, and free itself from the fetters of philosophy that would impede its progress; its mission is to seek truth calmly and confidently, its object to establish it beyond doubt or change, without any alarm as to the form under which it may make its appearance.

ON METEORIC STONES.[1]

By PROFESSOR N. S. MASKELYNE, M. A., F. R. S.

THE substantial unity of the celestial objects distinguished in common language by the names shooting or falling stars, fireballs, and meteorites, and further, the coincidence in many important respects of these with comets, and possibly with the zodiacal light, were suggestions made by Humboldt in the "Cosmos," which have received much confirmation from the subsequent advance of science.

The greater apparent velocity with which the ordinary meteors traverse the atmosphere as compared with that with which the less frequent larger bodies are seen to move, the marked periodicity that attends the recurrence of the former in several, and especially in two, notable cases of meteor-showers, offer an apparent contrast between these classes of meteors; it is not, however, in all probability, a real contrast, for the one class passes into the other by every gradation in the magnitude of the mass or masses of which the meteor consists, and consequently in the grandeur of the phenomena which accompany its advent. If of the material composing the ordinary falling star we have never yet been able to recognize any vestiges as reaching the earth, of the meteorite, on the other hand, the mineral collections of Europe contain numerous carefully-collected specimens, which are the fragments that have escaped the fiery ordeal of the transit through our earth's atmosphere, and in these we recognize masses composed either of iron (siderites), or of stones (aërolites), or of a mixture of the two (siderolites). The phenomena associated with such falls of meteoric matter have been described in very similar language by those who have witnessed them in various parts of the world, and these accounts, whether coming from European observers or from Hindoo herdsmen (of which some were read by the lecturer), concur generally in the approach of the meteorite as a fiery mass, emanating from a cloud when seen by day and exploding often with successive detonations that are heard over a great extent of country, even in certain cases at points more than 60 miles distant, but finally reaching the earth with a velocity little higher than what might be due to the motion of a falling body. Externally these meteoric masses are generally hot when they fall; sometimes, however, they are not so; the discrepancies in the accounts being explained by one authenticated case in which the mass was internally intensely cold, though at first hot externally. The fallen meteorite is invariably coated with an incrustation, sometimes shining as an enamel, generally black, but occasionally colorless where the aërolite is free from ferrous silicates; and this incrustation is seen to have been formed in the atmosphere,

[1] Read before the Royal Institution of Great Britain.

since it is found coating surfaces of fragments that have been severed by the explosions in the air.

Aërolites frequently fall simultaneously in large numbers, many thousands of them being in such cases spread over a surface of the country some miles in extent; and such showers of stones seem to have entered the atmosphere as a group, though their numbers must subsequently have been greatly increased by the division accompanying their detonation.

The explanation of the incrustation and of the cloud left by the meteorite, or out of which it seems to emerge, is found in the transformation into heat of the energy actuating a body that enters our atmosphere with a motion of 12 to 40 miles a second. The velocity of the body is almost instantaneously arrested by the atmospheric resistance, and in a very few seconds the mass becomes, comparatively speaking, stationary. Its surface must, as a consequence, be immediately fused, and the melted matter would be flung off from it into the surrounding air, fresh surfaces continually affording new fused material to form the cloud of, so to say, siliceous spray that lingers along and around the path of the meteorite.

When the mass is small—and in the case of meteoric showers and ordinary falling stars it cannot exceed a few ounces, and may often be but a few grains—the whole material is thus consumed, and must ultimately fall as an unperceived, because widely-scattered, dust. The meteorite is the residue that survives this wasting action where the magnitude of the mass is more considerable. The cause of the violent and often successive explosions is probably to be sought in the expansion of the outer portions of the mass, while the interior retains the contracted volume due to the intense cold of space with which the meteorite enters the atmosphere.

From time to time these contending conditions of volume may, as in a Prince Rupert's drop, produce explosion, the heated shell in the case of the meteorite flying off in fragments from the internally cold inner core, which if sufficient velocity remain to the mass will undergo a recurrence of the same conditions of surface fusion and explosion. The loudness of the detonation is also probably enhanced by the simultaneous collapse of the air on the vacuum that would follow the rapidly-moving mass.

The pitted surface characteristic of meteorites probably bears witness to a similar effect of unequal dilatation operating more especially in the freshly-broken surfaces of the mass, small fragments splintering off in this way from the cold and brittle stone under the sudden influence of intense heat.

A remark made by Humboldt, that light and meteorites are the only sources of our knowledge regarding the universe external to our world, points to the true ground for our interest in the waifs and strays of extra-telluric matter that thus fall upon our globe.

In physical as well as in chemical characters aërolites resemble at the first aspect some terrestrial volcanic rocks.

The minerals of which they are composed are nearly entirely crystalline, as is evinced by the colors in polarized light of such as are transparent. These minerals are usually aggregated with slight cohesion, and they present in by far the greatest number of cases a peculiar spherular or "*chondritic*" structure.

In these the spherules are composed of similar minerals to those which enclose them, and even contain metallic iron sometimes in microscopically fine grains disseminated through them.

A section of an aërolite was exhibited by the microscope in which some of the spherules had been broken before being cemented by the surrounding mass, and in another fissures were seen which had been filled with a fused material after one side of the fissure had slidden along the other; facts pointing to events in the history of the meteorite subsequent to its first formation.

The chemical composition and the mineral constitution of aërolites were illustrated by tables showing the elements met with in these bodies, and the minerals in which they were distributed. The former comprised about one-third of the known elements; among them magnesium, iron, silicon, oxygen, and sulphur, were conspicuous; calcium, aluminium, nickel, carbon, and phosphorus, coming next in importance, the basic elements of most importance by their amount being the same as those which are found by spectroscopic analysis to be present in the sun—and in those stars which have been the best examined.

The minerals most frequent in aërolites besides nickeliferous iron or troilite (iron monosulphide) and graphite, are bronzite (a ferriferous enstatite) and olivine, both of the latter being essentially magnesium silicates. Augite and anorthite also occur (more particularly in the eukritic aërolites of Rose) and some minerals unknown in terrestrial mineralogy have also been met with; such are the different varieties of Schreibersite (phosphides of iron and nickel); calcium sulphide, asmanite (a form of silica crystallizing in the orthorhombic system and having the specific gravity of fused quartz), and a cubic mineral with the composition of labradorite. The crystalline form of bronzite was first determined from the crystals in a meteorite, and was found to confirm the conclusion Descloizeaux had arrived at as regards its system from observations on the distribution of the optic axes in the terrestrial bronzite and enstatite.

The question as to whence the meteorites come is one that we are not yet in a position to answer with certainty. The various hypotheses which suppose for them an origin in lunar volcanoes, or in our atmosphere, or again in a destroyed telluric satellite, or that would treat them as fragments of an original planet of which the asteroids are parts, or as masses ejected from the sun; all these hypotheses seem to

be more or less precluded by the known velocities, the retrograde motion so frequently characterizing meteors and meteorites, or else by the chemical conditions that, for instance, are involved in the passage of the meteorite through the sun's chromosphere. Whether meteorites move or do not move in circumsolar orbits is at present impossible to say; because, while with our incomplete knowledge we cannot to-day attach the character of periodicity to any known class of meteorites, we are not justified in founding any conclusion on a negative result with so limited a foundation.

But even if all or some of them may have been, on their encountering the earth, members temporarily or permanently of the solar system, we may with considerable probability consider them as having originally entered our system from the interstellar spaces beyond it. Such at least must be our conclusion if we are to admit the unity of the whole class of phenomena of meteorites and falling stars. For, since the orbits of the two best-known meteoric streams, those namely of August and November, have been identified with the orbits of two comets, and since in regard to one of these (that of November) Leverrier has shown, with great probability, that as a meteoric cloud it entered and became a member of our system only some 1,700 years ago in consequence of the attraction of Uranus, while the August meteoric ring only differs in this respect from it, that it had at a much more remote period found an elliptic orbit round the sun: we are constrained on the assumption with which we started to recognize also in a meteorite a visitor from the regions of remote space. And so far as it goes, the observation by Secchi that the November falling stars exhibit the magnesium lines is in harmony with this view.

It may, however, further be said that the tendency of scientific conviction is in the direction of recognizing the collection toward and concentration in definite centres, of the matter of the universe, as a cosmical law, rather than the opposite supposition of such centres being the sources whence matter is dispersed into space. In the meteorites that fall on our earth (certainly in considerable numbers) we have to acknowledge the evidence of a vast and perpetual movement of space, about which we can only reason as part of a great feature in the universe which we have every ground for not supposing to be confined within the limits of the solar system.

That this matter, whether intercepted or not by the planets and the sun, should to an ever-increasing amount become entangled in the web of solar and planetary attraction, and that the same operation should be collecting round other stars and in distant systems such moving "clouds" of star-dust as have been treated by Schiaparelli, Leverrier, and other astronomers, or individual masses of wandering stone or iron, is a necessary deduction from the view that we have assumed regarding the tendency of cosmical matter to collect toward centres. But in order to trace the previous stages of the history of

any meteorite, and, in particular, to determine the conditions under which its present constitution as a rock took its origin, we have only for our guide the actual record written on the meteoric mass itself; and it is in this direction that the mineralogist is now working.

But the progress is necessarily a gradual one. We may indeed assert that the meteorites we know have, probably all of them, been originally formed under conditions from which the presence of water or of free oxygen to the amount requisite to oxidize entirely the elements present were excluded; for this is proved by the nature of the minerals constituting the meteorites, and by the way in which the metallic iron is distributed through them.

And one suggestive and significant fact remains to be alluded to; the presence, namely, in some few meteorites of combinations of hydrogen and carbon, which if met with in a terrestrial mineral would with little hesitation be assigned to an organic origin. A few grains were exhibited to the audience of such a body, crystallized from ether, which solvent had extracted it to the amount of about 0.25 per cent. from six ounces of the Cold Bokkveldt meteorite.

Similar substances have been extracted by Wöhler, Roscoe, and other chemists, from this and other meteorites. It was, however, observed, as pointing to the probability of the comparatively porous meteoric stone having in this case taken up the hydrocarbon as a substance extraneous to it (possibly when in the state of a vapor), that ether extracted it entirely from the solid lumps of the meteorite; pulverization not in any way adding to the amount obtained, or facilitating in any appreciable degree the separation of the substance.

SCIENCE AND RELIGION.

By PROFESSOR TYNDALL, LL. D., F. R. S.

THE editor of the *Contemporary Review* is liberal enough to grant me space for a few brief reflections on a subject, a former reference to which in these pages has, I believe, brought down upon him and me a considerable amount of animadversion.

It may be interesting to some if I glance at a few cases illustrative of the history of the human mind in relation to this and kindred subjects. In the fourth century the belief in Antipodes was deemed unscriptural and heretical. The pious Lactantius was as angry with the people who held this notion as my censors are with me, and quite as unsparing in his denunciations of their "Monstrosities." Lactantius was irritated because, in his mind, by education and habit, cosmogony and religion were indissolubly associated, and therefore simultaneously disturbed. In the early part of the seventeenth century the notion that

the earth was fixed, and that the sun and stars revolved round it daily, was interwoven in a similar manner with religious feeling, the separation then attempted by Galileo arousing animosity and kindling persecution. Men still living can remember the indignation excited by the first revelations of geology, regarding the age of the earth, the association between chronology and religion being for the time indissoluble. In our day, however, the best-informed clergymen are prepared to admit that our views of the Universe, and its Author, are not impaired, but improved, by the abandonment of the Mosaic account of the Creation. Look, finally, at the excitement caused by the publication of the "Origin of Species," and compare it with the calm attendant on the appearance of the far more outspoken, and, from the old point of view, more impious "Descent of Man."

Thus religion survives after the removal of what had been long considered essential to it. In our day the Antipodes are accepted, the fixity of the earth is given up, the period of Creation and the reputed age of the world are alike dissipated, Evolution is looked upon without terror, and other changes have occurred in the same direction too numerous to be dwelt upon here. In fact, from the earliest times to the present, religion has been undergoing a process of purification, freeing itself slowly and painfully from the physical errors which the busy and uninformed intellect mingled with the aspiration of the soul, and which ignorance sought to perpetuate. Some of us think a final act of purification remains to be performed, while others oppose this notion with the confidence and the warmth of ancient times. The bone of contention at present is *the physical value of prayer*. It is not my wish to excite surprise, much less to draw forth protest by the employment of this phrase. I would simply ask any intelligent person to look the problem honestly and steadily in the face, and then to say whether, in the estimation of the great body of those who sincerely resort to it, prayer does not, at all events upon special occasions, invoke a Power which checks and augments the descent of rain, which changes the force and direction of winds, which affects the growth of corn, and the health of men and cattle—a Power, in short, which, when appealed to under pressing circumstances, produces the precise effects caused by physical energy in the ordinary course of things. To any person who deals sincerely with the subject, and refuses to blur his moral vision by intellectual subtleties, this, I think, will appear a true statement of the case.

It is under this aspect alone that the scientific student, so far as I represent him, has any wish to meddle with prayer. Forced upon his attention as a form of physical energy, or as the equivalent of such energy, he claims the right of subjecting it to those methods of examination from which all our present knowledge of the physical universe is derived. And, if his researches lead him to a conclusion adverse to its claims—if his inquiries rivet him still closer to the philosophy

enfolded in the words, "He maketh his sun to shine on the evil and on the good, and sendeth rain upon the just and upon the unjust"—he contends only for the displacement of prayer, not for its extinction. He simply says, physical Nature is not its legitimate domain.

This conclusion, moreover, must be based on pure physical evidence, and not on any inherent unreasonableness in the act of prayer. The theory that the system of Nature is under the control of a Being who changes phenomena in compliance with the prayers of men, is, in my opinion, a perfectly legitimate one. It may of course be rendered futile by being associated with conceptions which contradict it, but such conceptions form no necessary part of the theory. It is a matter of experience that an earthly father, who is at the same time both wise and tender, listens to the requests of his children, and, if they do not ask amiss, takes pleasure in granting their requests. We know also that this compliance extends to the alteration, within certain limits, of the current of events on earth. With this suggestion offered by our experience, it is no departure from scientific method to place behind natural phenomena a universal Father, who, in answer to the prayers of His children, alters the currents of those phenomena. Thus far Theology and Science go hand in hand. The conception of an ether, for example, trembling with the waves of light, is suggested by the ordinary phenomena of wave-motion in water and in air; and in like manner the conception of personal volition in Nature is suggested by the ordinary action of man upon earth. I therefore urge no *impossibilities*, though you constantly charge me with doing so. I do not even urge inconsistency, but, on the contrary, frankly admit that you have as good a right to place your conception at the root of phenomena as I have to place mine.

But, without *verification*, a theoretic conception is a mere figment of the intellect, and I am sorry to find us parting company at this point. The region of theory, both in science and theology, lies behind the world of the senses, but the verification of theory occurs in the sensible world. To check the theory we have simply to compare the deductions from it with the facts of observation. If the deductions be in accordance with the facts, we accept the theory: if in opposition, the theory is given up. A single experiment is frequently devised by which the theory must stand or fall. Of this character was the determination of the velocity of light in liquids as a crucial test of the Emission Theory. According to Newton, light travelled faster in water than in air; according to an experiment suggested by Arago, and executed by Fizeau and Foucault, it travelled faster in air than in water. The experiment was conclusive against Newton's theory.

But while science cheerfully submits to this ordeal, it seems impossible to devise a mode of verification of their theory which does not arouse resentment in theological minds. Is it that, while the pleasure of the scientific man culminates in the demonstrated harmony

between theory and fact, the highest pleasure of the religious man has been already tasted in the very act of praying, prior to verification, any further effort in this direction being a mere disturbance of his peace? Or is it that we have before us a residue of that mysticism of the middle ages which has been so admirably described by Whewell —that "practice of referring things and events not to clear and distinct notions, not to general rules capable of direct verification, but to notions vague, distant, and vast, which we cannot bring into contact with facts; as when we connect natural events with moral and historic causes. . . . Thus," he continues, "the character of mysticism is that it refers particulars, not to generalizations, homogeneous and immediate, but to such as are heterogeneous and remote; to which we must add that the process of this reference is not a calm act of the intellect, but is accompanied with a glow of enthusiastic feeling."

Every feature here depicted, and some more questionable ones, have shown themselves of late; most conspicuously, I regret to say, in the "leaders" of a weekly journal of considerable influence, and one, on many grounds, entitled to the respect of thoughtful men. In the correspondence, however, published by the same journal, are to be found two or three letters well calculated to correct the temporary flightiness of the journal itself.

It is not my habit of mind to think otherwise than solemnly of the feeling which prompts prayer. It is a potency which I should like to see guided, not extinguished, devoted to practicable objects instead of wasted upon air. In some form or other, not yet evident, it may, as alleged, be necessary to man's highest culture. Certain it is that, while I rank many persons who employ it low in the scale of being, natural foolishness, bigotry, and intolerance, being in their case intensified by the notion that they have access to the ear of God, I regard others who employ it as forming part of the very cream of the earth. The faith that simply adds to the folly and ferocity of the one, is turned to enduring sweetness, holiness, abounding charity, and self-sacrifice, by the other. Christianity, in fact, varies with the nature upon which it falls. Often unreasonable, if not contemptible, in its purer forms prayer hints at disciplines which few of us can neglect without moral loss. But no good can come of giving it a delusive value by claiming for it a power in physical Nature. It may strengthen the heart to meet life's losses, and thus indirectly promote physical well-being, as the digging of Æsop's orchard brought a treasure of fertility greater than the treasure sought. Such indirect issues we all admit; but it would be simply dishonest to affirm that it is such issues that are always in view. Here, for the present, I must end. I ask no space to reply to those railers who make such free use of the terms insolence, outrage, profanity, and blasphemy. They obviously lack the sobriety of mind necessary to give accuracy to their statements, or to render their charges worthy of serious refutation.—*Advance Sheets.*

SPONTANEOUS GENERATION.

THE appearance of the long-promised work of Dr. Bastian on the "Beginnings of Life"[1] will be welcomed by the students of natural history as an important step forward in the progress of an old and interesting controversy. Whether all the life of the earth came from some primordial spark in the dim beginning, that has spread in multitudinous diversity through earth, sea, and air; or whether all forms of living things sprang into perfect existence after their distinctive kinds by a supernatural fiat; or whether the origination of living things is still within the compass of natural operations, are questions equally fascinating to pursue and difficult to determine. But the radical problem of the origin of life is now accepted as legitimate in the field of science, and much of the world's ablest talent is profoundly occupied with its investigation. We propose to give a brief account of Dr. Bastian's contribution to the inquiry, or rather to point out his line of research, referring those who are interested in the subject to his able work, which is now accessible to American readers.

The doctrine that certain forms of living things originate directly in the operations of Nature, without the agency of parentage, is an ancient speculation. Three centuries before the Christian era, Aristotle believed in the spontaneous origination of eels and other fish out of the slimy mud of rivers and marshes; also, that certain insects took origin from the vernal dew on plants; and that lice were spontaneously engendered in the flesh of animals. He believed also that animals might proceed from vegetables—that the caterpillars of certain butterflies, for instance, were actually the products of the plants upon which they fed. To the authority of Aristotle, which was despotic in the schools for nearly two thousand years, was added in this case the influence of poetry by which the Aristotlean science was popularized. Ovid, who is reputed to have been forty-three years old at the Christian era, sung of spontaneous generation as follows—Dryden being responsible for the English:

> "The rest of animals from teeming earth
> Produced, in various forms received their birth.
> The native moisture, in its close retreat
> Digested by the sun's ethereal heat
> As in a kindly womb, began to breed,
> Then swelled and quickened by the vital seed;
> And some in less, and some in longer space,
> Were ripened into form and took a several face.

[1] "The Beginnings of Life; being some Account of the Nature, Modes of Origin, and Transformations of Lower Organisms." By H. Charlton Bastian, M. A., M. D., F. R. S. In two volumes, pp. 1200; with numerous Illustrations.

Thus when the Nile from Pharian fields is fled,
And seeks, with ebbing tide, his ancient bed,
The fat manure with heavenly fire is warmed,
And crusted creatures, as in wombs, are formed;
These, when they turn the glebe, the peasants find;
Some rude, and yet unfinished in their kind.
Short of their limbs, a lame, imperfect birth;
One half alive, and one of lifeless earth."

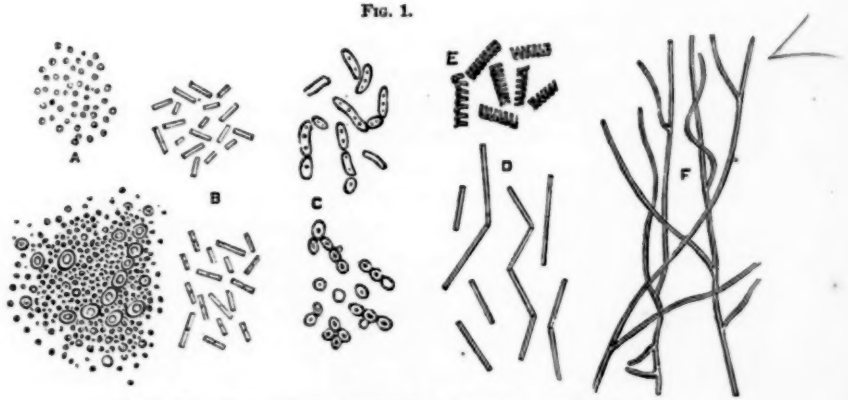
Crude ideas of this kind prevailed universally until the seventeenth century. The celebrated physiologist, Dr. William Harvey, the discoverer of the circulation of the blood, has the credit of first propounding the modern view expressed in the maxim "Omne vivum ex vivo," which being interpreted signifies, "No life without antecedent life." He maintained that all living beings proceed from eggs; but exactly what he meant by "eggs," that is, whether they were always derived from parental organisms, or might originate in some other way, is considered uncertain.

The first distinct announcement of the doctrine that all living matter has sprung from preëxisting living matter, was made by Francesco Redi, an Italian physician, who published his views just two hundred and four years ago. His position is thus stated by Prof. Huxley: "Here are dead animals, or pieces of meat; I expose them to the air in hot weather, and in a few days they swarm with maggots. You tell me that these are generated in the dead flesh; but, if I put similar bodies, while quite fresh, into a jar, and tie some fine gauze over the top of the jar, not a maggot makes its appearance, while the dead substances, nevertheless, putrefy just in the same way as before. It is obvious, therefore, that the maggots are not generated by the corruption of the meat, and that the cause of their formation must be a something which is kept away by gauze. But gauze will not keep away aëriform bodies or fluids. This something must, therefore, exist in the form of solid particles too big to get through the gauze. Nor is one left long in doubt what these solid particles are; for the blow-flies, attracted by the odor of the meat, swarm round the vessel, and urged by a powerful but in this case misleading instinct, lay eggs out of which maggots are immediately hatched upon the gauze. The conclusion, therefore, is unavoidable: the maggots are not generated by the meat, but the eggs which give rise to them are brought through the air by the flies."

These experiments were unanswerable; but the doctrine of spontaneous generation had been too long and firmly believed, to be surrendered merely because of the demonstrated falsity of its grounds. It was held to have the sanction of the Bible, which affirmed that bees were generated from the carcass of a dead lion: Dr. Redi was therefore called upon to defend himself against the charge of impugning Scripture authority.

The views of Redi prevailed for a century, and the hypothesis of spontaneous generation had become completely discredited. But meantime the microscope had been improved, and a new world of life revealed. When animal or vegetable substances are infused for a time in water, swarms of creatures are produced in it, called infusorial animalculæ, and which are so small that they can only be seen with a powerful magnifier. This was a new aspect of the production of life, and favored the view of its spontaneous origin. In the middle of the eighteenth century, an Englishman named Needham took the ground that, although putrefying meat may not engender *insects*, it may yet give rise to *animalculæ*. "If," said Needham, "these animalculæ come

FIG. 1.



SOME OF THE MOST COMMON PRIMORDIAL FORMS OF LIFE. (× 800.)
A. Plastide-particles; B. Bacteria; C. Torula; D. Vibriones; E. Spirilla; F. Leptothrix.

from germs, these germs must exist, either in the infused substance, the water, or the adjacent air. All germs are killed by heat; if, therefore, I boil the infusion, seal it up, and then heat the whole vessel, I shall destroy the germs." He did this; but, after waiting for a time, the animalculæ still appeared in the closed vessel. The experiment seemed conclusive in favor of spontaneous generation, or life without germs; but, again, a learned Italian appeared and attacked the hypothesis. Spallanzani repeated Needham's experiments with more vigilant precautions. He closed the tubes more effectually, and exposed them to a greater heat, after which the animalculæ failed to appear. The real issue in the case was thus fairly reached, and the question became one of the existence of atmospheric germs, and of their power of resisting heat. The results of Spallanzani were generally held conclusive against the hypothesis of spontaneous generation; but, toward the middle of the present century, the question was again opened, and it has been assiduously investigated and hotly discussed by men of science for the last forty years. We cannot even mention the numerous contributions to it that have been made by eminent scientists, but

must refer the reader to Dr. Bastian's work, where the history of recent investigations upon the subject is given in detail.

The growth of new distinctions and more precise ideas in science requires the use of new terms to mark them, while, at the same time, old terms have to be discarded, as conveying erroneous ideas. The term "spontaneous generation," although so long applied to the subject, that it will be apt to continue in popular use, has lost its place in biological science, as it is too indefinite, and conveys a false idea. Those who hold that life originates directly from non-living matter do not consider that its production in this way is any more truly "spontaneous" than its usual production from parental germs. Several words have been introduced by different writers to define their ideas, which it is desirable here to explain.

Biogenesis is the term applied by Prof. Huxley to the derivation of life from previously-existing life; and *Abiogenesis* to the production of life from non-living matter. The latter term, therefore, corresponds to what is commonly meant by "spontaneous generation."

Homogenesis, or *Homogeny*, are terms that have been long applied to the production of like from like; that is, the common case in which the living parent gives rise to offspring which pass through the same changes as itself.

Heterogenesis, or *Heterogeny*, is the name applied to processes by which living things arise from the matter of preëxisting organisms, belonging to a totally different species. It has, however, had different meanings, and its use has created some obscurity, but it is customary to apply it to the so-called cases of "spontaneous generation;" and those who hold this doctrine are therefore known as *Heterogenists*.

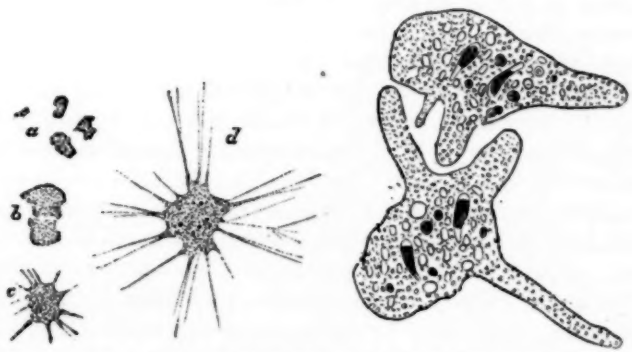
Panspermy is the name given to the doctrine of diffused atmospheric germs, as the sources of infusorial life, and those who hold to this view are called *Panspermists*. "Spontaneous generation," so called, or the production of living creatures without parentage, may take place in two ways: either from preëxisting living matter (heterogenesis), or from not-living matter. This production of living forms from inorganic materials is termed by Dr. Bastian *Archebiosis*, which literally means "beginning to live."

It was in the course of some investigations upon the microscopical characters of the blood of persons suffering from acute diseases that Dr. Bastian's attention was first drawn to the question of the origin of life. He soon became interested in it as an independent scientific problem, and pursued the inquiry experimentally for three years, the results being recorded in the present work. In Part I. he aims to show that the now commonly-accepted doctrine of the Correlation of Forces favors the independent origin of living matter. In this part, also, he has an elaborate chapter showing that the cell cannot be regarded as the ultimate organic unit. In Part II., under the head of Archebiosis, he takes up the real issue of the spontaneous generation

of new matter endowed with living properties. The question is thus stated: "It must be considered to turn almost wholly upon the possibility of the *de novo* origin of *bacteria;* since, if such a mode of origin can be proved for them, it must also be conceded for other allied fungoid and algoid units. Evidence, which is of the most convincing character when looked at from all sides, now shows that bacteria are killed by a temperature of 140° Fahr. Yet similar organisms will constantly appear and rapidly multiply within closed flasks containing organic fluids, although the flasks and their contents have been previously exposed for some time to a temperature of 212° Fahr."

As it will be impossible in this article to give the details of Dr. Bastian's experiments, we will try to convey to our readers some notion of these living organisms, which it is now claimed can be produced when all germs are destroyed. When a fluid containing an organic substance in solution is left to itself for a time, which may be variable in different circumstances, the infusion gradually becomes turbid, and there forms upon its surface a thin, semi-translucent scum,

FIG. 2.



REPRESENTATION OF HAECKEL'S GROUP MONERA. (× 800.) THE COMMON AMŒBA.

a. Minute Specks of Protoplasm from Fine Surface Mud of Fresh-water Ponds; *b.* Protomœba Primitiva, two Individuals resulting from a Recent Fission; *c.* Vampyrella Pendula; *d.* Amœba Porreta, a Form of Protomœba.

or pellicle, that soon thickens into a membrane. If the fluid be observed by a microscope of the highest power, when it first begins to grow clouded, it will be found swarming with multitudes of moving specks or spherical particles (Fig. 1, A), varying from $\frac{1}{20000}$ to $\frac{1}{100000}$ of an inch in diameter. These specks have been variously named. They have been called "monads," or "mycrozimes," or "micrococci," and are termed by Dr. Bastian *plastide-particles.* They are regarded by him as the primordial particles of living matter, and as giving origin to organisms of a higher grade.

Among these are the infusorial objects known as *bacteria* (Fig. 1, B). These are minute, rod-like, jointed bodies, varying in size according to

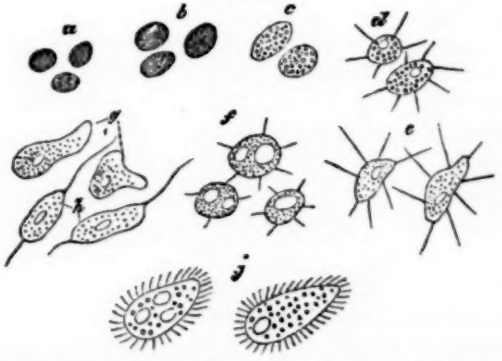
circumstances, but pretty uniform in the same solution. They are in length from $\frac{1}{15000}$ to $\frac{1}{2000}$ of an inch, and in thickness from $\frac{1}{30000}$ to $\frac{1}{40000}$ of an inch. The rods are formed of a series of granules placed end to end, and their appearance has been likened to a number of fine needles embedded in a thin film of glue. They often present a joint or line in the middle, dividing them into two equal parts. "Their movements are frequently of a more or less rapid, oscillating, or irregularly rotating character; though at other times they may be seen darting from place to place, either directly or in curves of various descriptions. All gradations exist, in fact, between movements which suffice at once to stamp them as living things, and mere slow oscillations, the presence of which alone may make us doubtful as to whether we have to do with living or dead organisms."

Along with the plastide-particles and the bacteria, there appears one of the lowest and simplest of organic bodies—the *Torula*, or yeast-plant (Fig. 1, C). The torula is a simple cell, possessing a cell-wall formed of a thin, homogeneous membrane, and containing a soft formative layer composed of protoplasm. These cells are about $\frac{1}{8000}$ of an inch and smaller, and multiply by budding or gemmation, being usually seen in chains, or clustered groups. *Vibriones* (Fig. 1, D) are described as jointed bodies, composed of long, rod-like segments, bent at various angles, which exhibit certain slow movements—either as mere bending of the body, or else an actual undulating progression. In size they may vary from that of the largest bacteria, up to a body $\frac{1}{500}$ of an inch in length, by $\frac{1}{12000}$ in breadth, though there is no definite limit to their dimensions. The *Spirilla* (Fig. 1, E) are less common organic forms, characterized by the most active movements, and in which the body is thread-like, though twisted into the form of a helix, or spiral. *Leptothrix* (Fig. 1 F) is a name applied to certain filamentous objects that are generally motionless, and often not much thicker than vibriones. They may be either straight or undulating in outline, and perfectly plain, or marked by minute segmentations, after the fashion of the larger fungous filaments, into which it is said they sometimes develop.

Within a few years past, attention has been called by Prof. Haeckel to certain of the lowest forms of organic life, which he considers intermediate between the animal and vegetable kingdoms, and by which they are connected. These he calls the PROTISTA, meaning, first of all, primordial. This primordial organic kingdom, Haeckel divides into ten groups, the lowest of which he names the *Monera*, which includes certain minute jelly-specks termed *protomœba* and *protogenes*. Prof. Haeckel says: "I have called these forms of life standing at the lowest grade of organization *monera*. Their whole body, in a fully-developed and freely-moving condition, consists of an entirely homogeneous and structureless substance, a living particle of albumen capable of nourishment and reproduction. These simplest and most imperfect of all

organisms are, in many respects, of the highest interest. For the albumen-like, organic matter meets us here as the material substratum of all life-phenomena, apparently not only under the simplest form as yet actually observed, but also under the simplest form which can well be imagined. Simpler and more incomplete organisms than the monera cannot be conceived. . . . Indeed, the whole body of the monera, however strange this may sound, represents nothing more than a single, thoroughly homogeneous particle of albumen, in a firmly adhesive condition. The external form is quite irregular, continually changing, globularly contracted when at rest. Our sharpest discrimination can detect no trace of an internal structure, or of a formation from dissimilar parts. As the homogeneous, albuminous mass of the body of the moner does not even exhibit a differentiation into an inner nucleus and an outer plasma, and as, moreover, the whole body consists of a homogeneous plasma or protoplasma, the organic matter here does not even reach the importance of the simplest cell. It remains in the lowest imaginable grade of organic individuality." Prof. Haeckel afterward says: "The monera are indeed protista. They are neither animals nor plants. They are organisms of the most primitive kind; among which the distinction between animals and plants does not exist."

FIG. 8.



TRANSFORMATIONS OF CHLOROPHYLL CORPUSCLES. (× 600.)

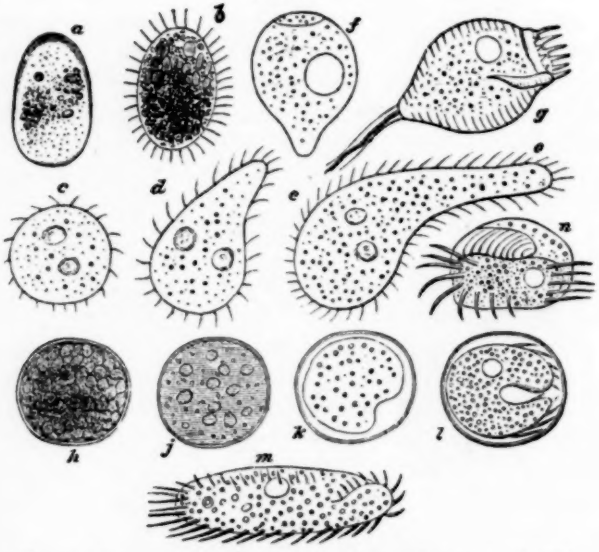
a, Pale, unaltered Chlorophyll Corpuscles of Nitella; *b*, Others lying side by side with former, but larger, of a darker green, and slightly granular; *c*, Decolorization advancing—a few granules still green; *d*, Similar corpuscles after the protrusion of motionless rays, and formation of a vacuole; *e*, Similar corpuscles completely decolorized and converted into sluggish specimens of Actinophrys; *f*, First stage in transformation of Actinophrys, some of which are converted into Amœbæ (*g*), and others into Monads (*h*) with two flagella; *j*, Enchelys-like organisms, probably derived from further development of some Monads and Amœbæ.

The common amœba is described as a microscopic animal at the very bottom of the scale of living things. It is a minute, shapeless, structureless mass of semi-fluid jelly or protoplasm, without organs of any kind, but it has the marvellous power of extemporizing organs as it requires them. Thus, if it wishes to move, it shoots out a part of its body as a temporary foot, and retracts it when no longer wanted.

If it desires to seize any thing, it protrudes an arm for the purpose; and, when it has in this way got possession of the needed nutriment, becoming all stomach, it wraps itself round its food, and absorbs or digests it.

Dr. Carpenter describes it as "changing itself into a greater variety of forms than the fabled Proteus, laying hold of its food without members, swallowing it without a mouth, digesting it without a stomach, appropriating its nutritious material without absorbent vessels or a circulating system, moving from place to place without muscles, feeling (if it has any power to do so) without nerves, multiplying itself without eggs, and not only this, but, in many instances, forming shelly coverings of a symmetry and complexity not surpassed by those of any testaceous animal."

FIG. 4.



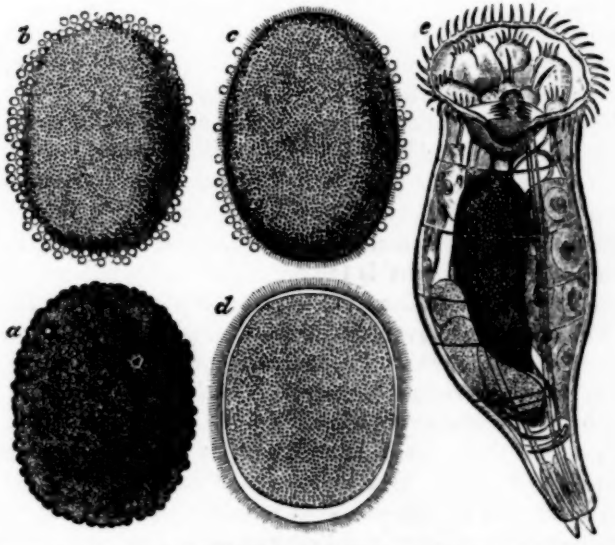
MODES OF ORIGIN AND DEVELOPMENT OF CILIATED INFUSORIA. (×600.)

a, Transforming Euglena, with red "eye-speck" still visible; *b*, A similar body, having many of its chlorophyll corpuscles still green, fringed with almost motionless cilia; *c*, A completely decolorized sphere derived from a transformed Euglena, provided with a few partly-motionless cilia; *d* and *e*, More advanced forms of a similar embryo developing into a Dileptus (?); *f*, Vorticella, soon after its emergence from a cyst of Euglena origin, which subsequently develops into a striated variety (*g*); *h*, A large Chlorococcus-vesicle, whose contents gradually undergo decolorization (*j*), and at last becomes converted into an animalized mass (*k*), which gradually shapes itself into the form of an Oxytricha (*l*). This after a time ruptures its cyst and soon takes on the characteristics shown at *m*; *n*, A form of Pleuroconia derived from an embryo produced within other, apparently similar, Chlorococcus-vesicles.

The experiments of Dr. Bastian force upon him the conclusion that the several organisms here considered, bacteria, torula, vibriones, fungus-filaments, protomœba, and monads, are products of the direct development of new-born specks of living matter. His experiments seem to have been conducted with extreme precautions. He hermetically closed the narrow necks of his flasks during violent ebullition, thus producing an almost perfect vacuum above the infusion. After

this he subjected the flasks to a heat of from 212° Fahr. to over 400° Fahr. After being left a few days under favorable situations, and then examined, they were found to contain the living creatures we have described. The only remaining question is, Could these organisms or their germs survive this degree of heat? The alternative to which the opponents of spontaneous generation seem to be driven, by these investigations, is thus pointedly stated by Mr. Alfred Russell Wallace, in a late review of Dr. Bastian's book, in *Nature*. He says: "The only way of escaping from the results of such a series of experiments as that here recorded is by asserting that, although the *organisms* which are produced in the flasks are killed by a temperature much below that

FIG. 5.



TRANSFORMATION OF A MASS OF CHLOROCOCCUS CORPUSCLES INTO THE SO-CALLED "WINTER-EGG" OF *Hydatina senta*. (× 250.)

a, Ovoid mass of bright-green Chlorococcus Corpuscles, about $\frac{1}{250}$ in long diameter; *b*, Such a mass after its transformation into a brown granular body, without distinct bounding wall (should have been intermediate in tint between *a* and *c*); *c*, A similar body at a later stage, when a limiting envelop has made its appearance, upon which villous outgrowths had been produced; *d*, Later stage, constituting the so-called "winter-egg" of *Hydatina*; *e*, *Hydatina senta* which is produced from such a body—almost adult.

to which the flasks have been subjected, the *germs* from which they have been produced are not so killed. We are asked, therefore, to accept as facts three pure suppositions: first, that such excessively minute and simple organisms as bacteria, whose only mode of multiplication is by fission or gemmation, have germs which possess different physical properties from themselves; secondly, that these germs, as well as many others, are omnipresent in the atmosphere; and, thirdly, that they are not injured by an exposure for four hours to vapor heated to over 300° Fahr.; and, finally, we are to accept all

these suppositions as facts in order to avoid admitting that specks of living protoplasm are originated *de novo* in some fluids just as specks of crystalline matter originate in other fluids, and although some organisms can be seen to make their appearance in fluids independently of all preëxisting visible germs, just as crystals do."

In Part III., Dr. Bastian takes up the processes of heterogenesis, whereby the matter of already existing living units gives birth to other living things, wholly different from themselves, and having no tendency to revert to the parental type. The transformations and developments represented in Figs. 3, 4, and 5, will mainly interest those familiar with the objects delineated, but they are of a very remarkable character. It is alleged that the cells of confervæ give rise to euglena, a beautiful green organism which abounds in stagnant water, while this undergoes still further transformation into amœba, and ciliated infusoria. And still more surprising, if possible, is the transformation of the minute algoid chlorococcus into the large, complex, and well-known rotifer, *Hydatina senta* (Fig. 5).

As Dr. Bastian remarks: "The fact that animals with such distinct and specific organs should arise in this definite manner, from the reproductive products of the plant, will doubtless seem to many to flavor more of fable than of fact." This is undoubtedly true. Dr. Bastian's views contravene general experience. The derivation of organisms from preëxisting germs is the actual method which we know that Nature employs in all grades from the top to the bottom of the scale of life. We know, moreover, that infusorial germs do exist, and float about, in the atmosphere. Besides, all our past knowledge of life implies the slow operation of the forces of evolution. As for the appearance of infusorial organisms in liquids, which a few hours before did not contain them, they must be explained in accordance with known modes of action, until some other method is demonstrated. To this, Dr. Bastian replies—1. That science now admits that, at some period in the earth's history, the lower forms of life have arisen by the operation of natural causes. 2. That all the considerations bearing upon the case favor the view that such organisms may be produced now, and that it is little else than absurd to suppose that "the simplest and most structureless amœba of the present day can boast a line of ancestors stretching back to such far-remote periods that in comparison with them the primeval men were but as things of yesterday;" and 3. That the *de novo* origin of living matter, and the transformation of low vegetable organisms into infusoria and animalcula are facts that must now be considered as experimentally established. The whole question will therefore turn on the future testing of these remarkable processes. The subject cannot be allowed to rest here; and, if Dr. Bastian's experiments shall be verified, the publication of his work will constitute an epoch in the progress of biological science. It may be remarked that the "Beginnings of Life" is written in a popular and

intelligible style, but, as it was composed while the doctor was absorbed in his investigations, it is somewhat defective in classification and condensation. This is to be regretted, yet it is quite a secondary matter. Mr. Wallace deprecates its literary defects, but cordially concedes its scientific importance. He says: "It is so full of curious and novel facts and experiments, it contains so much excellent reasoning and acute criticism, and it opens up such new and astounding views of the nature and origin of life, that one feels it ought to and might have ranked with such standard works as the 'Origin of Species' and the 'Principles of Biology,' if equal care had been bestowed upon it as a literary composition."

AIMS AND INSTRUMENTS OF SCIENTIFIC THOUGHT.[1]

By Professor W. KINGDON CLIFFORD,

of University College, London.

I.

IT may have occurred (and very naturally, too, to such as have had the curiostity to read the title of this lecture) that it must necessarily be a very dry and difficult subject; interesting to very few, intelligible to still fewer, and, above all, utterly incapable of adequate treatment within the limits of a discourse like this. It is quite true that a complete setting forth of my subject would require a comprehensive treatise on logic, with incidental discussion of the main questions of metaphysics; that it would deal with ideas demanding close study for their apprehension, and investigations requiring a peculiar taste to relish them. It is not my intention now to present you with such a treatise.

The British Association, like the world in general, contains three classes of persons. In the first place, it contains scientific thinkers; that is to say, persons whose thoughts have very frequently the characters which I shall presently describe. Secondly, it contains persons who are engaged in work upon what are called scientific subjects, but who in general do not, and are not expected to, think about these subjects in a scientific manner. Lastly, it contains persons who suppose that their work and their thoughts are unscientific, but who would like to know something about the business of the other two classes aforesaid. Now, to any one who, belonging to one of these classes, considers either of the other two, it will be apparent that there is a certain gulf between him and them; that he does not quite understand them, nor they him; and that an opportunity for sympathy and com-

[1] A Lecture delivered before the members of the British Association, at Brighton, August 19, 1872.

radeship is lost through this want of understanding. It is this gulf that I desire to bridge over, to the best of my power. That the scientific thinker may consider his business in relation to the great life of mankind; that the noble army of practical workers may recognize their fellowship with the outer world, and the spirit which must guide both; that this so-called outer world may see in the work of science only the putting in evidence of all that is excellent in its own work; may feel that the kingdom of science is within it: these are the objects of the present discourse. And they compel me to choose such portions of my vast subject as shall be intelligible to all, while they ought at least to command an interest universal, personal, and profound.

In the first place, then, what is meant by scientific thought? You may have heard some of it expressed in the various sections this morning. You have probably also heard expressed in the same places a great deal of unscientific thought; notwithstanding that it was about mechanical energy, or about hydrocarbons, or about eocene deposits, or about malacopterygii. For scientific thought does not mean thought about scientific subjects with long names. There are no scientific subjects. The subject of science is the human universe; that is to say, every thing that is, or has been, or may be, related to man. Let us, then, taking several topics in succession, endeavor to make out in what cases thought about them is scientific, and in what cases not.

Ancient astronomers observed that the relative motions of the sun and moon recurred all over again in the same order about every nineteen years. They were thus enabled to predict the time at which eclipses would take place. A calculator at one of our observatories can do a great deal more this. Like them, he makes use of past experience to predict the future; but he knows of a great number of other cycles besides that one of the nineteen years, and takes account of all of them; and he can tell about the solar eclipse of six years hence—exactly where it will be visible, and how much of the sun's surface will be covered at each place, and, to a second, at what time of day it will begin and finish there. This prediction involves technical skill of the highest order; but it does not involve scientific thought, as any astronomer will tell you.

By such calculations the places of the planet Uranus at different times of the year have been predicted and set down. The predictions were not fulfilled. Then arose Adams, and from these errors in the prediction he calculated the place of an entirely new planet, that had never yet been suspected; and you all know how the new planet was actually found in that place. Now, this prediction does involve scientific thought, as any one who has studied it will tell you.

Here, then, are two cases of thought about the same subject, both predicting events by the application of previous experience, yet we say one is *technical* and the other *scientific*.

Now, let us take an example from the building of bridges and roofs. When an opening is to be spanned over by a material construction, which must bear a certain weight without bending enough to injure itself, there are two forms in which this construction can be made, the arch and the chain. Every part of an arch is compressed or pushed by the other parts; every part of a chain is in a state of tension, or is pulled by the other parts. In many cases these forms are united. A girder consists of two main pieces or booms, of which the upper one acts as an arch and is compressed, while the lower one acts as a chain and is pulled; and this is true even when both the pieces are quite straight. They are enabled to act in this way by being tied together, or braced, as it is called, by cross-pieces, which you must often have seen. Now, suppose that any good, practical engineer makes a bridge or roof upon some approved pattern which has been made before. He designs the size and shape of it to suit the opening which has to be spanned; selects his material according to the locality; assigns the strength which must be given to the several parts of the structure according to the load which it will have to bear. There is a great deal of thought in the making of this design, whose success is predicted by the application of previous experience; it requires technical skill of a very high order; but it is not scientific thought. On the other hand, Mr. Fleeming Jenkin[1] designs a roof consisting of two arches braced together, instead of an arch and a chain braced together; and, although this form is quite different from any known structure, yet before it is built he assigns with accuracy the amount of material that must be put into every part of the structure in order to make it bear the required load, and this prediction may be trusted with perfect security. What is the natural comment on this? Why, that Mr. Fleeming Jenkin is a scientific engineer.

Now, it seems to me that the difference between scientific and merely technical thought, not only in these, but in all other instances which I have considered, is just this: Both of them make use of experience to direct human action; but while technical thought or skill enables a man to deal with the same circumstances that he has met with before, scientific thought enables him to deal with different circumstances that he has never met with before. But how can experience of one thing enable us to deal with another quite different thing? To answer this question we shall have to consider more closely the nature of scientific thought.

Let us take another example. You know that if you make a dot on a piece of paper, and then hold a piece of Iceland spar over it, you will see not one dot but two. A mineralogist, by measuring the angles of a crystal, can tell you whether or no it possesses this property without looking through it. He requires no scientific thought to do that. But Sir William Rowan Hamilton, the late Astronomer-Royal

[1] "On Braced Arches and Suspension Bridges." Edinburgh, Neill, 1870.

of Ireland, knowing these facts and also the explanation of them which Fresnel had given, thought about the subject, and he predicted that, by looking through certain crystals in a particular direction, we should see not two dots, but a continuous circle. Mr. Lloyd made the experiment, and saw the circle, a result which had never been even suspected. This has always been considered one of most signal instances of scientific thought in the domain of physics. It is most distinctly an application of experience, gained under certain circumstances, to entirely different circumstances.

Now, suppose that, the night before coming down to Brighton, you had dreamed of a railway accident, caused by the engine getting frightened at a flock of sheep, and jumping suddenly back over all the carriages; the result of which was that your head was unfortunately cut off, so that you had to put it in your hat-box, and take it back home to be mended. There are, I fear, many persons, even at this day, who would tell you that, after such a dream, it was unwise to travel by railway to Brighton. This is a proposal that you should take experience gained while you are asleep, when you have no common-sense—experience about a phantom-railway—and apply it to guide you when you are awake, and have common-sense, in your dealings with a real railway. And yet this proposal is not dictated by scientific thought.

Now, let us take the great example of biology. I pass over the process of classification, which itself requires a great deal of scientific thought, in particular when a naturalist, who has studied and monographed a fauna or a flora rather than a family, is able at once to pick out the distinguishing characters required for the subdivision of an order quite new to him. Suppose that we possess all this minute and comprehensive knowledge of plants and animals and intermediate organisms, their affinities and differences, their structures and functions—a vast body of experience, collected by incalculable labor and devotion. Then comes Mr. Herbert Spencer; he takes that experience of life which is not human, which is apparently stationary, going on in exactly the same way from year to year, and he applies that to tell us how to deal with the changing characters of human nature and human society. How is it that experience of this sort, vast as it is, can guide us in a matter so different from itself? How does scientific thought, applied to the development of a kangaroo-fœtus, or the movement of the sap in exogens, make prediction possible for the first time in that most important of all sciences, the relations of man with man?

In the dark or unscientific ages men had another way of applying experience to altered circumstances. They believed, for example, that the plant called jew's-ear, which does bear a certain resemblance to the human ear, was a useful cure for diseases of that organ. This doctrine of "signatures," as it was called, exercised an enormous influence on the medicine of the time. I need hardly tell you that it is hopelessly unscientific; yet it agrees with those other examples that we have

been considering in this particular: that it applies experience about the shape of a plant—which is one circumstance connected with it—to dealings with its medicinal properties, which are other and different circumstances. Again, suppose that you had been frightened by a thunder-storm on land, or your heart had failed you in a storm at sea; if any one then told you that, in consequence of this, you should always cultivate an unpleasant sensation in the pit of your stomach, till you took delight in it—that you should regulate your sane and sober life by the sensations of a moment of unreasoning terror; this advice would not be an example of scientific thought. Yet it would be an application of past experience to new and different circumstances.

But you will already have observed what is the additional clause that we must add to our definition in order to describe scientific thought, and that only. The step between experience about animals and dealings with changing humanity is the law of evolution. The step from errors in the calculated places of Uranus to the existence of Neptune is the law of gravitation. The step from the observed behavior of crystals to conical refraction is made up of laws of light and geometry. The step from old bridges to new ones is the laws of elasticity and the strength of materials.

The step, then, from past experience to new circumstances must be made in accordance with an observed uniformity in the order of events. This uniformity has held good in the past in certain places; if it should also hold good in the future, and in other places, then, being combined with our experience of the past, it enables us to predict the future, and to know what is going on elsewhere, so that we are able to regulate our conduct in accordance with this knowledge.

The aim of scientific thought, then, is to apply past experience to new circumstances: the instrument is an observed uniformity in the course of events. By the use of this instrument it gives us information transcending our experience, it enables us to infer things that we have not seen from things that we have seen; and the evidence for the truth of that information depends on our supposing that the uniformity holds good beyond our experience. I now want to consider this uniformity a little more closely, to show how the character of scientific thought and the force of its inferences depend upon the character of the uniformity of Nature. I cannot, of course, tell you all that is known of this character without writing an encyclopædia, but I shall confine myself to two points of it, about which, it seems to me, that just now there is something to be said. I want to find out what we mean when we say that the uniformity of Nature is *exact;* and what we mean when we say that it is *reasonable.*

When a student is first introduced to those sciences which have come under the dominion of mathematics, a new and wonderful aspect of Nature bursts upon his view. He has been accustomed to regard things as essentially more or less vague. All the facts that he has

hitherto known have been expressed qualitatively, with a little allowance for error on either side. Things which are let go fall to the ground. A very observant man may know also that they fall faster as they go along. But our student is shown that, after falling for one second in a vacuum, a body is going at the rate of thirty-two feet per second; that after falling for two seconds it is going twice as fast; after going two and a half seconds, two and a half times as fast. If he makes the experiment, and finds a single inch per second too much or too little in the rate, one of two things must have happened: either the law of falling bodies has been wrongly stated, or the experiment is not accurate—there is some mistake. He finds reason to think that the latter is always the case: the more carefully he goes to work, the more of the error turns out to belong to the experiment. Again, he may know that water consists of two gases, oxygen and hydrogen, combined; but he now learns that two pints of steam at a temperature of 150° centigrade will always make two pints of hydrogen and one pint of oxygen at the same temperature, all of them being pressed as much as the atmosphere is pressed. If he makes the experiment and gets rather more or less than a pint of oxygen, is the law disproved? No; the steam was impure, or there was some mistake. Myriads of analyses attest the law of combining volumes; the more carefully they are made, the more nearly they coincide with it. The aspects of the faces of a crystal are connected together by a geometrical law, by which, four of them being given, the rest can be found. The place of a planet at a given time is calculated by the law of gravitation; if it is half a second wrong, the fault is in the instrument, the observer, the clock, or the law; now, the more observations are made, the more of this fault is brought home to the instrument, the observer, and the clock. It is no wonder, then, that our student, contemplating these and many like instances, should be led to say: "I have been short-sighted; but I have now put on the spectacles of science which Nature had prepared for my eyes; I see that things have definite outlines, that the world is ruled by exact and rigid mathematical laws; *καὶ σύ, θεός, γεωμετρεῖς*." It is our business to consider whether he is right in so concluding. Is the uniformity of Nature absolutely exact, or only more exact than our experiments?

At this point we have to make a very important distinction. There are two ways in which a law may be inaccurate. The first way is exemplified by that law of Galileo which I mentioned just now: that a body falling *in vacuo* acquires equal increase in velocity in equal times. No matter how many feet per second it is going, after an interval of a second it will be going thirty-two *more* feet per second. We now know that this rate of increase is not exactly the same at different heights, that it depends upon the distance of the body from the centre of the earth; so that the law is only approximate; instead of the increase of velocity being exactly *equal* in equal times, it itself

increases very slowly as the body falls. We know also that this variation of the law from the truth is *too small to be perceived* by direct observation on the change of velocity. But suppose we have invented means for observing this, and have verified that the increase of velocity is inversely as the squared distance from the earth's centre. Still the law is not accurate; for the earth does not attract accurately toward her centre, and the direction of attraction is continually varying with the motion of the sea; the body will not even fall in a straight line. The sun and the planets, too, especially the moon, will produce deviations; yet the sum of all these errors will escape our new process of observation, by being a great deal smaller than the necessary errors of that observation. But when these again have been allowed for, there is still the influence of the stars. In this case, however, we only give up one exact law for another. It may still be held that if the effect of every particle of matter in the universe on the falling body were calculated according to the law of gravitation, the body would move exactly as this calculation required. And if it were objected that the body must be slightly magnetic or diamagnetic, while there are magnets not an infinite way off; that a very minute repulsion, even at sensible distances, accompanies the attraction; it might be replied that these phenomena are themselves subject to exact laws, and that, when *all* the laws have been taken into account, the actual motion will exactly correspond with the calculated motion.

I suppose there is hardly a physical student (unless he has specially considered the matter) who would not at once assent to the statement I have just made; that, if we knew all about it, Nature would be found universally subject to exact numerical laws. But let us just consider for another moment what this means.

The word "exact" has a practical and a theoretical meaning. When a grocer weighs you out a certain quantity of sugar very carefully, and says it is exactly a pound, he means that the difference between the mass of the sugar and that of the pound-weight he employs is too small to be detected by his scales. If a chemist had made a special investigation, wishing to be as accurate as he could, and told you this was exactly a pound of sugar, he would mean that the mass of the sugar differed from that of a certain standard piece of platinum by a quantity too small to be detected by *his* means of weighing, which are a thousandfold more accurate than the grocer's. But what would a mathematician mean, if he made the same statement? He would mean this. Suppose the mass of the standard pound to be represented by a length, say a foot, measured on a certain line; so that half a pound would be represented by six inches, and so on. And let the difference between the mass of the sugar and that of the standard pound be drawn upon the same line to the same scale. Then, if that difference were magnified an infinite number of times, it would still be invisible. This is the theoretical meaning of exactness; the

practical meaning is only very close approximation; *how* close, depends upon the circumstances. The knowledge, then, of an exact law in the theoretical sense would be equivalent to an infinite observation. I do not say that such knowledge is impossible to man; but I do say that it would be absolutely different in kind from any knowledge that we possess at present.

I shall be told, no doubt, that we do possess a great deal of knowledge of this kind, in the form of geometry and mechanics; and that it is just the example of these sciences that has led men to look for exactness in other quarters. If this had been said to me in the last century, I should not have known what to reply. But it happens that about the beginning of the present century the foundations of geometry were criticised independently by two mathematicians, Lobatschewsky [1] and the immortal Gauss; [2] whose results have been extended and generalized more recently by Riemann [3] and Helmholtz.[4] And the conclusion to which these investigations lead is that although the assumptions which were very properly made by the ancient geometers are practically exact—that is to say, more exact than experiment can be—for such finite things as we have to deal with, and such portions of space as we can reach; yet the truth of them for very much larger things, or very much smaller things, or parts of space which are at present beyond our reach, is a matter to be decided by experiment, when its powers are considerably increased. I want to make as clear as possible the real state of this question at present, because it is often supposed to be a question of words or metaphysics, whereas it is a very distinct and simple question of fact. I am supposed to know, then, that the three angles of a rectilinear triangle are exactly equal to two right angles. Now, suppose that three points are taken in space, distant from one another as far as the sun is from α Centauri, and that the shortest distances between these points are drawn so as to form a triangle. And suppose the angles of this triangle to be very accurately measured and added together; this can at present be done so accurately that the error shall certainly be less than one minute, less therefore than the five-thousandth part of a right angle. Then I do not know that this sum would differ at all from two right angles; but also I do not know that the difference would be less than ten degrees, or the ninth part of a right angle.[5] And I have reasons for not knowing.

This example is exceedingly important as showing the connection

[1] "*Geometrische Untersuchungen zur Theorie der Parallellinien*," Berlin, 1840. Translated by Hoüel, Gauthier-Villars, 1866.

[2] Letter to Schumacher, November 28, 1846 (refers to 1792).

[3] "*Ueber die Hypothesen welche der Geometrie zu Grunde liegen*," Göttingen Abhandl., 1866–'67. Translated by Hoüel in *Annali di Matematica*, Milan, vol. iii.

[4] "The Axioms of Geometry," Academy, vol. i., p. 128 (a popular exposition).

[5] Assuming that parallax observations prove the deviation less than half a second for a triangle whose vertex is at the star and base a diameter of the earth's orbit.

between exactness and universality. It is found that the deviation, if it exists, must be nearly proportional to the area of the triangle. So that the error in the case of a triangle whose sides are a mile long would be obtained by dividing that in the case I have just been considering by four hundred quadrillions; the result must be a quantity inconceivably small, which no experiment could detect. But between this inconceivably small error and no error at all, there is fixed an enormous gulf—the gulf between practical and theoretical exactness, and what is even more important, the gulf between what is practically universal and what is theoretically universal. I say that a law is practically universal which is more exact than experiment for all cases that might be got at by such experiment as we have. We assume this kind of universality, and we find that it pays us to assume it. But a law would be theoretically universal if it were true of all cases whatever; and this is what we do not know of any law at all.

I said there were two ways in which a law might be inexact. There is a law of gases which asserts that when you compress a perfect gas the pressure of the gas increases exactly in the proportion in which the volume diminishes. Exactly; that is to say, the law is more accurate than the experiment, and experiments are corrected by means of the law. But it so happens that this law has been explained; we know precisely what it is that happens when a gas is compressed. We know that a gas consists of a vast number of separate molecules, rushing about in all directions with all manner of velocities, but so that the mean velocity of the molecules of air in this room, for example, is about twenty miles a minute. The pressure of the gas on any surface with which it is in contact is nothing more than the impact of these small particles upon it. On any surface large enough to be seen there are millions of these impacts in a second. If the space in which the gas is confined be diminished, the average rate at which the impacts take place will be increased in the same proportion; and, because of the enormous number of them, the actual rate is always exceedingly close to the average. But the law is one of statistics; its accuracy depends on the enormous numbers involved; and so, from the nature of the case, its exactness cannot be theoretical or absolute.

Nearly all the laws of gases have received these statistical explanations; electric and magnetic attraction and repulsion have been treated in a similar manner; and an hypothesis of this sort has been suggested even for the law of gravity. On the other hand, the manner in which the molecules of a gas interfere with each other proves that they repel one another inversely as the fifth power of the distance; so that we here find, at the basis of a statistical explanation, a law which has the form of theoretical exactness. Which of these forms is to win? It seems to me, again, that we do not know, and that the recognition of our ignorance is the surest way to get rid of it.

The world, in general, has made just the remark that I have attrib-

uted to a fresh student of the applied sciences. As the discoveries of Galileo, Kepler, Newton, Dalton, Cavendish, Gauss, displayed ever-new phenomena following mathematical laws, the theoretical exactness of the physical universe was taken for granted. Now, when people are hopelessly ignorant of a thing, they quarrel about the source of their knowledge. Accordingly, many maintained that we know these exact laws by intuition. These said always one true thing, that we did not know them from experience. Others said that they were really given in the facts, and adopted ingenious ways of hiding the gulf between the two. Others, again, deduced from transcendental considerations sometimes the laws themselves, and sometimes what, through imperfect information, they supposed to be the laws. But more serious consequences arose when these conceptions derived from physics were carried over into the field of Biology. Sharp lines of division were made between kingdoms, and classes, and orders; an animal was described as a miracle to the vegetable world; specific differences, which are practically permanent within the range of history, were regarded as permanent through all time; a sharp line was drawn between organic and inorganic matter. Further investigation, however, has shown that accuracy had been prematurely attributed to the science, and has filled up all the gulfs and gaps that hasty observers had invented. The animal and vegetable kingdoms have a debatable ground between them, occupied by beings that have the characters of both, and yet belong distinctly to neither. Classes and orders shade into one another all along their common boundary. Specific differences turn out to be the work of time. The line dividing organic matter from inorganic, if drawn to-day, must be moved to-morrow to another place; and the chemist will tell you that the distinction has now no place in his science except in a technical sense for the convenience of studying carbon compounds by themselves. In geology the same tendency gave birth to the doctrine of distinct periods, marked out by the character of the strata deposited in them all over the sea; a doctrine than which, perhaps, no ancient cosmogony has been further from the truth, or done more harm to the progress of science. Refuted many years ago by Mr. Herbert Spencer,[1] it has now fairly yielded to an attack from all sides at once, and may be left in peace.

When, then, we say that the uniformity which we observe in the course of events is exact and universal, we mean no more than this: that we are able to state general rules which are far more exact than direct experiment, and which apply to all cases that we are at present likely to come across. It is important to notice, however, the effect of such exactness as we observe upon the nature of inference. When a telegram arrived stating that Dr. Livingstone had been found by Mr. Stanley, what was the process by which you inferred the finding of

[1] "Illogical Geology," in *Essays*, vol. i. Originally published in 1859.

Dr. Livingstone from the appearance of the telegram? You assumed over and over again the existence of uniformity in Nature. That the newspapers had behaved as they generally do in regard to telegraphic messages; that the clerks had followed the known laws of the action of clerks; that electricity had behaved in the cable exactly as it behaves in the laboratory; that the actions of Mr. Stanley were related to his motives by the same uniformities that affect the actions of other men; that Dr. Livingstone's handwriting conformed to the curious rule by which an ordinary man's handwriting may be recognized as having persistent characteristics even at different periods of his life. But you had a right to be much more sure about some of these inferences than about others. The law of electricity was known with practical exactness, and the conclusions derived from it were the surest things of all—the law about the handwriting, belonging to a portion of physiology which is unconnected with consciousness, was known with less, but still with considerable accuracy. But the laws of human action in which consciousness is concerned are still so far from being completely analyzed and reduced to an exact form, that the inferences which you made by their help were felt to have only a provisional force. It is possible that by-and-by, when psychology has made enormous advances and become an exact science, we may be able to give to testimony the sort of weight which we give to the inferences of physical science. It will then be possible to conceive a case which will show how completely the whole process of inference depends on our assumption of uniformity. Suppose that testimony, having reached the ideal force I have imagined, were to assert that a certain river runs up-hill? You could infer nothing at all. The arm of inference would be paralyzed, and the sword of truth broken in its grasp; and reason could only sit down and wait until recovery restored her limb, and further experience gave her new weapons.—*Advance Sheets from Macmillan.*

SKETCH OF PROFESSOR TYNDALL.

THE Tyndall or Tyndale family emerged into history about the same time as the American Continent. The first of whom we hear was William Tyndale, a contemporary of Columbus, and who was just of age when this country was discovered. It was the epoch of intellectual awakening in Europe, and the impulse was felt equally in geographical exploration and in religious reform. Tyndale took to the latter, and translated the Bible into English for the people. But he found worse navigation on the theological sea than Columbus en-

countered on the Atlantic, and was burned at the stake for his opinions in 1536.

About the middle of the seventeenth century some of the offshoots of the martyr's family emigrated from Gloucestershire, England, to Ireland, on the eastern or Saxon fringe of which some of their descendants are still scattered. Among these was John Tyndall, the Professor's father, who, although unknown to the public, was a man of unusual intellectual power and force of character. The Tyndall blood seems to have been rather fiery, as Prof. Tyndall's father had a "difference" with his grandfather, which cost him the inheritance that he would have otherwise received as the eldest son. He was therefore left to struggle without means, and learned a trade, but subsequently took a position on the police force of Ireland. But, being denied the usual facilities of education, he taught himself upon various subjects, and especially he became an able student of history. Prof. Tyndall's father inherited from his ancestors a taste for religious controversy, and threw himself zealously as an anti-Romanist into the Protestant and Catholic warfare. The fathers of the English Church, Chillingworth, Tillotson, Faber, Poole, Jeremy Taylor, and a host of others, were at his finger's ends. Young Tyndall's early intellectual discipline consisted almost wholly of exercises in theological controversy, on the doctrines of infallibility, purgatory, transubstantiation, and invocation of the saints. The boy knew the Bible almost by heart, and, with reference to this knowledge, his father used to call him Stillingfleet. But he had also an early interest in natural things, and his father flattered this tendency by calling him Newton, and by teaching him lines concerning the great natural philosopher, before he was seven years old, that are still remembered. The father of Prof. Tyndall was not only intellectually gifted, but he was a man of courage, independence, mental delicacy, and scrupulous honor. By the silent influence of his character, by example as well as by precept, he inspired the intellect of his boy, and taught him to love a life of manly independence. He died in May, 1847, quoting to his son the words of Wolsey to Cromwell—"Be just and fear nothing."

The subject of our present sketch was born in the village of Leighlin Bridge, Ireland, in 1820, and his earliest education was received at a school in that neighborhood. Through the influence of one of his teachers, he acquired an early taste for geometry. In 1839 he quitted school and joined the Irish Ordnance Survey. He acquired a practical knowledge of every branch of it, becoming in turn a draughtsman, a computer, a surveyor, and trigonometrical observer. In subsequent years he turned this experience to admirable account in his investigations of alpine glaciers. In 1841 an incident occurred which, although apparently trivial, had a powerful effect upon the young man's career. One of the officials, who had become interested in Tyndall's work, asked him one day how his leisure hours were employed. The answer

not being satisfactory, he rejoined, "You have five hours a day at your disposal, and this time ought to be devoted to systematic study. Had I, when at your age, had a friend to advise me, as I now advise you, instead of being in a subordinate position, I might have been at the head of the Survey." Next morning Tyndall was at his books before five o'clock, and for twelve years never swerved from the pratice.

In 1844, seeing no definite prospect before him, Mr. Tyndall resolved to go to America, whither, in the early part of the present century, some members of his father's family had emigrated, and who now reside in Philadelphia.[1] This was, however, opposed by his friends, and, an opening occurring, he entered upon the vocation of a railroad engineer. To five years upon the Ordnance Survey succeeded three years of railway experience. But, this proving unpromising, and animated by a strong desire to augment his knowledge, Mr. Tyndall resigned his position, and accepted an appointment in Queenswood College, Hampshire—a new institution devoted partly to a junior school and partly to the preliminary technical education of agriculturists and engineers. Prof. Tyndall here developed a remarkable capacity as a teacher. Although totally inexperienced in this field, such was his magnetic influence over the students, that he was invariably called upon to compose their disturbances, which he did by moral influences and pure force of character. It was his experience in this institution that gave him the groundwork of his masterly address on education before the Royal Institution.[2]

In 1848, in company with his friend Frankland (now Prof. Frankland, of the Royal School of Chemistry), Tyndall quitted England, and, attracted by the fame of Prof. Bunsen, repaired to the University of Marburg, in Hesse-Cassel. Prof. Tyndall had the free use of the laboratory and cabinets of this institution, with the instructions of Bunsen, Gerling, Knoblauch, and Stegman. His first scientific paper was a mathematical essay on screw-surfaces, which formed the subject of his inaugural dissertation when he took his degree. But the investigation which first made him known to the scientific world was "On the Magne-optic Properties of Crystals, and the Relation of Magnetism and Diamagnetism to Molecular Arrangement." This investigation was executed in connection with Prof. Knoblauch, and was published in the *Philosophical Magazine* for 1850.

In 1851 Mr. Tyndall went to Berlin, and continued his researches in the laboratory of Prof. Magnus. He soon, however, returned to London, and was elected Fellow of the Royal Society in 1852. He was invited to give a Friday evening discourse at the Royal Institution, which he delivered February 14, 1853, and was so successful that

[1] One of these is Hector Tyndale, who distinguished himself as an officer in the late war. At Antietam he fought as major, and for his gallant behavior was subsequently made brigadier-general.

[2] *See* "Culture demanded by Modern Life." D. Appleton & Co.

he was at once offered a position in that establishment. His election to the appointment which he now holds, of Professor of Natural Philosophy at the Royal Institution, was unanimously made in June, 1853. The first three years of his residence in London he devoted to an exhaustive investigation of diamagnetism, the results of which were published in various memoirs that have since been collected in a volume.

Prof. Tyndall was first attracted to the Alps in 1849, for the sole object of healthful recreation and exercise. But he could not be long in the presence of the grand physical phenomena there displayed without becoming interested in the scientific questions they present. Accordingly, for more than twenty years, the Alps have served the double purpose to Prof. Tyndall of physical and mental reinvigoration, after being run down by his London work; and, at the same time, they have furnished him with a series of the most interesting scientific problems. In company with his friends Prof. Huxley and Prof. Hirst (an old and favorite pupil of Tyndall's, and to whom he dedicated his "Hours of Exercise in the Alps"), and often alone, usually in summer, but sometimes in winter, he has climbed the mountains and explored the Glaciers, to clear up the various questions that have arisen, and extend our knowledge of the subject. The description of his adventures and the results of his researches were embodied in his volume on "The Glaciers of the Alps," but which is now out of print. The reader will, however, find the records of adventure, and the results of study in the mountains, embodied in the "Hours of Exercise," published last year, and in a neat little volume on the "Forms of Water," now just issued from the press.

As we remarked last month, Prof. Tyndall's proclivity is for philosophic physics, and all his various lines of research, since he began in the Marburg laboratory, twenty-four years ago, have converged upon the great question of the molecular constitution of matter. The different forces of Nature, and the several divisions of physics, can only be brought into scientific harmony as they are harmonized in Nature, by arriving at some clear understanding of the common constitution of matter and how it is related to the action of forces. Prof. Tyndall has been a profound student of the correlation of these forces, and of the mechanism of that material substratum through which they are manifested. Taking up matter in its free or vaporous condition, his chief problem has been to explore or to *sound* it by the action of the radiant forces. In his work on "Heat as a Mode of Motion," published in 1863, he develops that modern view of the nature of heat which involves a molecular conception of the bodies displaying it. The results of his original researches into the relations of radiant heat to gases and vapors are there summarized, and his full memoirs upon these investigations have just been published in a companion volume to the work on diamagnetism. His interesting little volume on "Sound," although not designed as a statement of original work, takes up the subject of

acoustics from the same general point of view, and deals with atmospheric wave-motion in connection with the properties and constitution of the various forms of matter. The researches on the formation of clouds in tubes filled with various gases and vapors under the influence of the electric beam, and the resulting inquiry into the subject of atmospheric dust, were but parts of the same comprehensive investigation into molecular conditions and transformations.

Prof. Tyndall has won his scientific reputation as an explorer in the field of experimental physics, but he has also a commanding position as a philosophic thinker. The questions that can be resolved by experiment lead on to questions that can be resolved only by reason. Philosophy is old and easy, and the human mind has overflowed with it from the beginning; but philosophy grounded in the knowledge and method of science is as yet rare, though it is nevertheless a glorious reality. If scientific thinking is the result of an apprenticeship of centuries in the management of the intellect, and if the mind's scientific action is its most perfect action, then must scientific men, as the world goes on, be more and more trusted in their opinions. Such is undoubtedly the present tendency. This is shown generally in the increasing recognition of the scientific school of philosophy, and it is specially exemplified, in the present case, by the interest that is taken in whatever Prof. Tyndall has to say to the public, and whatever the subject on which he speaks. This high scientific position gives acknowledged weight and force to his views. But Prof. Tyndall's philosophic cast of mind not only attracts him to the deeper questions of the time, but his courageous temper leads him to deal with them candidly and fearlessly. First of all, a devotee of science and a lover of truth, he gives to these his sole allegiance. An independent and intrepid inquirer, tolerant of honest error, but contemptuous of that timid and calculating spirit which would protect men's prejudices from the light of investigation, he is without fear in the free and manly expressions of his opinions. That these should often contravene prevailing beliefs is inevitable. A Protestant by hereditary instinct and in his blood, and long drilled in the severities of scientific logic, it is impossible that he should not find much in current opinion to excite continued and trenchant protest.

Allied with this cherished freedom of thought and utterance, there is in Prof. Tyndall's character an intense love of justice, and a passion for fair dealing that is quite chivalric. This temper has been displayed on various occasions, but in none more conspicuously than in his generous defence of the German physicist, Mayer, whose scientific claims he considered to be depreciated by English scientists. Mayer's had been a hard fate. An undoubted pioneer in establishing the important doctrine of the correlation of forces, working out its several lines of proof with marvellous sagacity and an amount of exhausting labor that resulted in mental derangement, and with little sympathetic recognition

on the part of his own countrymen, Prof. Tyndall was indignant that Englishmen, who pride themselves upon fair play, should detract one iota from the just fame of the unfortunate foreigner. The man was unknown to him, but the rights of the discoverer and the honor of science were involved, and against the attacks of Professors Thomson, Tait, and others, Prof. Tyndall made a defence so effectual that the claims of the German philosopher will hardly be brought in question again.

Of Prof. Tyndall as an author, it is hardly necessary to speak, as his various works have been widely circulated, and the reading public is familiar with them. Yet his genius as a writer is so marked that it cannot be omitted even in the briefest sketch of his character. Among scientific writers he stands almost alone in the poetic vividness, force, and finish of his style. His descriptions and narrations are enriched by a bold and striking pictorial imagery, which presents the subject with almost the perspective and "coloring of reality." No man better understands the high office of imagination in science, or can more effectively employ it to fascinate and illuminate the minds of others. Of an ardent and poetic temperament, and at home among the grandeurs of natural phenomena, there is often an inspiration in his words that rouses and thrills our highest feelings.

Prof. Tyndall is now among us, to speak upon science in several of the chief cities of the country, and it is therefore as a lecturer that the public will be chiefly interested in him. We quote an excellent account of his characteristics as a public teacher from the October *Galaxy*:

"Prof. Tyndall's manner as a lecturer is in a remarkable degree individual and unique. He never reads, but holds his audience by the power of lucid and forcible extemporaneous statement. He is not what would be called a fluent or even speaker, who keeps up a continuous strain of agreeable utterance. He is not an elegant declaimer, whose measured cadences are accompanied by graceful and appropriate gestures. He is irregular and sometimes hesitating in speech, and unstudied in gestures and movements. His habit of speaking has been formed in connection with his habit of experimenting, and this latter is so essential a feature of his platform exercises that it greatly influences his manner of public address. Clearness, force, vividness of description, felicity of illustration, and the eloquence inspired by grand conceptions are the striking features of his style. Of a poetic and imaginative temperament, but with these traits under thorough discipline, he gives vivacity and attractiveness to accurate and solid exposition. Prof. Tyndall is a thoroughly-trained and well-poised enthusiast in science. He is intensely in earnest, and is always as much interested in the subject and the proceedings as the audience he carries with him. He is a remarkable example of self-forgetfulness upon the platform, being always absorbed in his subject. Strongly sympathetic with his audience, he seems animated by but one purpose: to make them understand the question before them, to make them see it and feel it as he sees and feels it. As an original and skilful experimenter Prof. Tyndall is unrivalled. Fertile and ingenious in contrivances for bringing out his points, the effects are always telling and im-

pressive. Yet the experiments are never the main things; they are always subordinate to the idea with which he is dealing—helps to its presentation. He is never eclipsed by his own pyrotechny, but holds the attention of his listeners closely to the question under examination. Prof. Tyndall is remarkable for the combination of two traits which are but rarely united in a single individual. He is an original explorer of scientific truth, and a skilful and effective public teacher. Holding the truths of science to be divine, he is impelled to dedicate his life to their discovery; but holding them also to be a means of salvation to man, he is impelled also to the duty of their public interpretation. The Royal Institution, in which he is professor, is admirably constituted for the attainment of this twofold end; providing equally for carrying out systematic original researches and for expounding their results to the select audiences that gather in its lecture-room. Sir Humphry Davy first gave it a world-wide reputation in both these departments; he was a fertile discoverer and an eloquent lecturer. Dr. Faraday succeeded him, and probably surpassed him in both of these accomplishments. The mantle of Faraday has fallen upon Tyndall, and the fame of the establishment has not suffered from the change."

Prof. Tyndall has long desired to visit the United States, to see his many friends, and to observe the aspects of American life; while multitudes in this country have reciprocated the desire, that they might have the opportunity of listening to his lectures. Yielding to their numerous appeals, he has prepared a course of six lectures, and brought with him a large amount of new and delicate apparatus, for illustrating them. The lectures will embrace the phenomena and laws of light: reflection, refraction, analysis, synthesis, the doctrine of colors, and the extension of radiant action in both directions, beyond the light-giving rays into the region of invisible action. Then will follow the principles of spectrum analysis, the polarization of light, the phenomena of crystallization, the action of crystals upon light, the chromatic phenomena of polarized light, and the parallel phenomena of light and radiant heat. These lectures will be a source of rare intellectual enjoyment to those who will have the good fortune to listen to them, and of which our citizens will not be slow to avail themselves.

We give, in the present number of the MONTHLY, the best likeness we have ever seen of Prof. Tyndall. He is a man of medium stature, lithe-built, highly vitalized, alert and noiseless in his movements; a ready and effective talker, but an excellent listener, and his manners are genial and attractive. He is socially strong, a man of the world, as well as a philosopher, and at home in all relations. But, with all his passion for experiment, he has not yet made the experiment of matrimony.

EDITOR'S TABLE.

THE DOCTRINE OF EVOLUTION.

THE editor of *Scribner's Magazine*, in a leading article in the October number, attempts to bring THE POPULAR SCIENCE MONTHLY into reproach for its obnoxious opinions. There is a certain doctrine lately much talked about that is known to be odious among a great number of magazine-buying people. It is charged (on what authority is not stated) that the editor of THE POPULAR SCIENCE MONTHLY is an irrepressible partisan of this doctrine, and that, having made certain specious promises to its readers to furnish them with good, sound, scientific reading, he has betrayed their confidence by setting his pages ablaze with expositions of this doctrine, that so many people are known to regard with detestation. The little game here undertaken is old, and has been often played with success; but, with the growth of intelligence and liberality, it is getting disreputable, and our neighbor is welcome to all he can make by it. It is customary in such cases not to be very scrupulous about the means resorted to for effecting the object, and the present instance is no exception to the custom. The editor commences by trying to be ironical about the claims of science in culture, and quotes from our prospectus the remark that it is "of the highest concern that thought should be brought into the exactest harmony with things." We are still of opinion that the neglect of this requirement is the fundamental defect of education, and we venture to intimate to our critic that this is exactly "what's the matter with him." His statements not only fail to harmonize with the things he is talking about, but they grossly misrepresent them. After quoting some sentences from our prospectus, the editor says:

"It is therefore painful to find that, when we pass from the well-taken prospectus to the actual monthly, the strict inductive inquiry fades softly away, as in a dissolving view, and in its place blazes out one of the most high-flown of human speculations. The strong bias of the editor as an evolutionist cannot be repressed, and the attempt is made to educate the public mind into the phraseology and methods of what is at best a speculation, under the name of science! If this were called the Youmans, or Evolution Monthly, the mischief would be circumscribed; but, as the doctrine of Evolution, with its offspring, Darwinism, is nothing more yet than a provisional hypothesis, based on *a priori* reasonings, and not on any valid induction of facts, the attempt to clothe it in the imperial garb of science, and set it for an arbiter of all beliefs, is greatly to be deprecated in the interest of true culture."

The statement here made, that under editorial bias our pages have been set ablaze with evolution speculations in violation of prospective pledges, is simply not true. We promised our readers to represent the present state of thought on the leading questions that are agitating the scientific world. The doctrine of evolution, as everybody knows, is one of these questions, and had we avoided it we should have broken our promise, and broken faith with our readers. Nor has the subject received the excessive attention that is charged. Our first volume, just completed, contains about a hundred main or leading articles, and of these but three deal with the subject of Evolution or Darwinism, and one of them is an attack upon its fundamental principle. Of the articles contributed by the editor, not one has been devoted to the object alleged—"that of educating the pop-

ular mind into the phraseology and methods of this speculation." Nor is there a single article in the whole volume that gives any explanation of either the phraseology or the methods of the doctrine of Evolution. A few references to it there have been, as in the addresses of Dr. Carpenter and Prof. Gray, before eminent scientific bodies, and as occurs in the able article of Prof. Clifford in the present number; but these references are incidental and unavoidable: they result from the prominence of the question in the scientific world, and its consequent recognition in current scientific literature. And yet it pleases the editor of *Scribner's* to tell his readers that under an uncontrolled personal bias our pages are so fired with this mischievous doctrine that the name of the MONTHLY ought to be changed to prevent its evil influence.

It now remains to consider the more serious imputation, that our pages have been perverted to the diffusion of spurious science. According to the editor of *Scribner's*, the doctrine of evolution is not a result of true science—not an induction from facts, but a "high-flown," "*a priori*" "speculation." And here, again, we have to note that this writer is not very particular to make his thought harmonize with the things he is talking about. His statement is as wrong as he could get it—just 180° from the truth; and, if the ignorance he evinces be any measure of the general ignorance, we cannot too quickly begin the neglected work of "educating the popular mind" into the rudiments of the subject. We purpose now to show that the Hypothesis of Evolution is not an *a priori* speculation, but a true scientific induction; and not only so, but it is the antagonist and successor of *a priori* speculations which had been in vogue for many centuries before the inductive method arose.

What is the fundamental conception of the doctrine of Evolution? It is "that the universe and all that it contains did not come into existence in the condition that we now know it, nor in any thing like that condition." It implies that the heavens as they appear above us, the earth as it exists beneath us, the hosts of living creatures that occupy it, and humanity as we now know it, "are merely the final terms in an immense series of changes, which have been brought about in the course of immeasurable time." It affirms vast changes in past periods; that these changes have been according to a method, and that this method has been of the nature of an unfolding. The essential changes of evolution have been comprehensively formulated as from the simple to the complex, from the homogeneous to the heterogeneous, from the general to the special. Is this an *a priori* speculation, that is, an idea formed before observation and experience of the facts to which it applies; or is it a scientific induction, that is, an idea formed after the facts are known, and based upon them?

As regards the stellar and planetary universe, its origin from an all-diffused nebulous mist was taught by Kant a century ago. This view was subsequently elaborated by Laplace the mathemetician, and Herschel the astronomer, into the Nebular Hypothesis, which was the outcome of the whole body of known astronomical facts. This hypothesis affirmed the progressive condensation and differentiation of the nebulous mass through successive stages to more and more concrete and specialized groups, systems, and orbs. That the solar system was gradually formed in the way the nebular hypothesis implies, and that its facts can be explained by that hypothesis and no other, is now the general belief of astronomers. Consisting of more than one hundred and fifty bodies, revolving and circulating according to one grand method, it has been pointed out

by Prof. Leconte that there are no less than three hundred and seventy facts concerning the distribution, form, and motions, of the sun and planets, which are the simple consequences of the nebular hypothesis, and can be accounted for in no other way. The nebular hypothesis is the doctrine of to-day, in its application to the most perfect of the sciences, and it is nothing less or other than an hypothesis of astronomic evolution. Are we to be told that it is but an *a priori* speculation? On the contrary, has it not replaced an *a priori* cosmogony that swayed the human mind for thousands of years before the solar system was discovered?

As regards the earth, it has been studied by the method of science for more than a century, and the result is, a vast mass of facts and inductions which make up our knowledge of geology. All these go to establish one proposition, viz., that our planet is not what it was millions of years ago, but has undergone a series of developing changes resulting in the present order of things. Our eminent geologist, Prof. Dana, in his manual, says: "This law of specialization—the general being before the special—is the law of all development. The egg is at first a simple unit, and, gradually, part after part of the new structure is evolved, that which is most fundamental appearing earliest, until the being is complete in all its outer and minor details. The principle is exhibited in the physical history of the globe—which was first a featureless globe of fire, then had its oceans and dry land, in course of time received mountains and rivers, and finally all those diversities of surface which now characterize it. Again, the climates began with universal tropics; and at last the diversities of the present day." Is this to be accounted a high-flown *a priori* speculation, or a vast and valid induction from a hundred years' study of the facts of Nature? Let it be remembered that, according to the highest authorities, inductive geology was put back two centuries by the enslavement of the human mind to an old *a priori* speculation in regard to the age of the world.

The study of the course of life upon the earth shows that it conforms to the same great plan. The life of the globe a few millions of years ago was a very different thing from what it is now. Different races of plants and animals have appeared and disappeared in slow succession, and their remains are found entombed in successive rock-formations. The facts are a part of geology, and have been arrived at by the same processes of observation and induction that have revealed the order and history of the stratified systems. The course of life upon the earth has conformed to a method, and that method is universally described as a progress and a development. It shows an advance from the simpler to the more complex, from the general to the special, from the lower to the higher; in short, it is an evolution in the strictest sense. There was, first, a period of no life—the azoic age; then appeared the lower forms of life, vegetable and animal; then higher and higher kinds, until man, the highest of all, appeared last. The progress evinces continuity, harmony, and gradation. As remarked by Mr. Dana, "the beginning of an age will be in the midst of a preceding age; and the marks of the future coming out to view are to be regarded as prophetic of that future. The age of mammals was foreshadowed by the appearance of mammals long before in the course of the reptilian age, and the age of reptiles was prophesied in types that lived in the earlier Carboniferous age." The lower forms that perish do not reappear, and, as Mr. Wallace observes, "no group or species has come into existence twice," but "every species has come into existence coincident, both in space and time, with a preëxisting, closely-allied species."

That the great advancing movement of life has been a divergence, an opening out, or an evolution, is incontestable, and is admitted by the highest biological authorities. It is proved by the fact that, if we go back a million of years or so, there is an obvious convergence of types, or the different kinds of animals will have to be represented as nearer together in characters, and, as we recede still farther into the past, the approximation becomes still closer. Prof. Owen says he has "never omitted a proper opportunity for impressing the results of observations showing the more generalized structures of extinct, as compared with the more specialized form of recent animals." Prof. Agassiz takes a similar position, insisting strongly that "The more ancient animals resemble the embryonic forms of existing species." Mr. Wallace says: "As we go back into past time and meet with the fossil remains of more and more ancient races of extinct animals we find that many of them actually are intermediate between distinct groups of existing animals." Prof. Cope remarks: "That the existing state of the geological record of organic types should be regarded as any thing but a fragment is, from our stand-point, quite preposterous. And more, it may be assumed with safety, that when completed, it will furnish us with a series of regular successions, with but slight and regular interruptions, if any, from the species which represented the simplest beginnings of life at the dawn of creation, to those which have displayed complication and power in a later or in the present period. For the labors of the paleontologist are daily bringing to light structures intermediate between those never before so connected, thus creating lines of succession where before were only interruptions." Is the great conclusion of an unfolding method in the order of life which is based upon a vast body of biological facts, and supported by the powerful analogies of an unfolding order in other parts of nature, to be characterized as a high-flown *a priori* speculation? or is it a result of strict inductive inquiry, which replaces an *a priori* hypothesis of life that prevailed for ages before science had entered upon its study?

Again, humanity is not now what it was in ages long past. That man's existence upon earth dates back to a far profounder antiquity than has formerly been believed, is a clear induction from an extensive array of facts. Be the time longer or shorter, an immense series of changes has taken place in the history of the race. A few thousand years ago Europe was barbarous, and its inhabitants warred and worked with implements of stone. Society was rude, low, homogeneous, and undeveloped. Its movement has been a slow unfolding into diversity and specialty. There has been an increase of human capabilities, a rise in intelligence, an advance of morals, a growing capacity of social coöperation, a multiplication of arts and industries, augmented power over Nature, an emergence of institutions, and in short an evolution of civilization. This is a broad induction, from the facts of history, from the facts of prehistoric archæology, and from the facts of anthropology, and it is fast taking the place of the old *a priori* speculation that the course of humanity has been a degeneracy, and which was firmly believed until science reversed the method of studying the subject.

Sir Charles Lyell, it will hardly be denied, is one of the most learned and able of living geologists. His painstaking conscientiousness as an observer and his judicial caution and calmness as an inductive reasoner are beyond question. For fifty years he has studied the subject of life in connection with the past changes of the globe, and has embodied his conclusions in his various geological works. In the earlier of

these works, which passed through many editions, he accepted the old traditional view of the origin of life. But, as his studies enlarged, that view broke down so completely that he has formally abandoned it. In the tenth edition of his "Principles of Geology," published in 1867, and in the eleventh edition of the same work now just issued, he has adopted the theory of evolution in its application to the phenomena of terrestrial life. The presidents of the British Association for the Advancement of Science, Grove, Hooker, Huxley, and Carpenter, in their inaugural addresses, and Prof. Gray in his late address as president of the American Scientific Association, have proclaimed their adherence to the doctrine of evolution. Prof. Cope, one of the most able and accomplished of American zoologists, affirms that the truth of the development hypothesis is held "to be infinitely probable by a majority of the exponents of the natural sciences, and is held as absolutely demonstrated by another portion." It has been widely accepted by the younger naturalists of this country, more generally by those of England, and still more extensively by those of Germany, as a guiding principle in the work of investigation. An intelligent German naturalist said to Prof. Giekie, of the Edinburgh University: "You are still discussing in England whether or not the theory of Darwin can be true. We have got a long way beyond that here. His theory is now our common starting-point."

Facts like these will have weight with thoughtful persons, but the editor of *Scribner's* sees through the illusion. All these masters of science and working-students of Nature have been lured from the path of true induction by the *ignis fatuus* of a high-flown *a priori* speculation.

We have shown the separate establishment of a principle of evolution by independent workers in different branches of science. On the broad basis of the facts and inductions that have been reached by three centuries of investigation in the several domains of natural phenomena, rests the hypothesis of *universal evolution*. The coordination of these diverse and alien orders of facts, and the synthesis of inductions, by which the grand generalization was arrived at, we owe to the genius of Herbert Spencer. With a knowledge of modern science that John Stuart Mill has pronounced "encyclopedic," with a grasp of method and a capacity of organization which, on the authority of the *Saturday Review*, has not been equalled in England since Newton, and with the power of a "giant mind," as Dr. McCosh declares, to wield and shape his extensive scientific materials, Mr. Spencer has worked out the principle of universal evolution by the rigid logic of inductive science. In each division of his exposition the first step has been to marshal the facts; to sift and methodize the data. The next step has been to generalize the facts, or to establish the inductions warranted by the data. Finally he verifies these inductions by showing that they follow from previously established principles, and harmonize with them. The conditions by which all science has been created are thus strictly complied with. The conception of all nature, as in a slow process of movement to a higher state—of an ever-advancing and ever-perfecting order—of a *universe in evolution*, is no fantastic speculation brought down to us by tradition from the dreaming childhood of the race, but it is a definite verifiable principle educed from a more comprehensive range of facts than any other generalization ever attempted—the outgrowth of the ripest knowledge, and which is coercing the assent of the most disciplined intellects of the world. The principle in question is no barren formula to be classed with the

empty *a priori* speculations which have figured so largely in the past career of the human mind. It is the result of the steady concentration of the intellect of man for hundreds of years upon the realities that surround us, and is the profoundest answer yet given to man's questionings of the mystery of being. It is the latest interpretation of the ongoings of the world, and brings with it the possibility of a new and more stable philosophy of things than we have yet known—a philosophy not spun from mystical *a priori* fancies, but constructed from the valid truths of science, and anchored in the depths of demonstrated knowledge.

An able writer in the *Quarterly Review* (London) for July, in discussing the modern school of thought and Herbert Spencer's relation to it, says: "The two deepest scientific principles now known of all those relating to material things are, the law of gravitation and the law of evolution." The principle is here recognized as more than a hypothesis and more even than a theory, it is a *law* in the same sense that gravitation is a law. The proof of evolution indeed is very far from being so complete as that of gravitation. But its claims as an established law are not therefore invalidated, for the accepted truths of science by no means rest upon equal amounts of evidence. From the newness of the systematic investigation of the principle, from the imperfection of knowledge in many spheres of its application, and from the stupendous reach of its operation, it is impossible that there should not be many deficiencies in its proof. It has its outstanding and unresolved difficulties which it may take long to clear up. Truths grow—they are examples of evolution. All great generalizations have been arrived at gradually; never at once by complete demonstration. There are first long foreshadowing preludes in which a principle is discerned as emerging into increasing distinctness. It is then accepted on grounds of probability, and preponderating proofs, and as an advance on previous beliefs. If a theory becomes increasingly consonant with facts, and steadily makes way against inexorable criticism, though it has grave difficulties, it will be accepted, and these difficulties will be left to the future. It was so with the law of gravitation. "The Newtonian theory was beset by palpable contradictions in its results till many years after Newton's death, yet all sound philosophers embraced it. The motion of the apsides of the moon's orbit was with singular honesty confessed by Newton to be, in fact, nearly twice as great as calculation from theory made it; and this contradiction remained an outstanding, palpable objection, yet without occasioning any misgiving as to the general truth of gravitation, until the error was explained and the calculation rectified by Clairault."

And so it is in other branches of science. The undulating theory of light is accepted by all physicists, but still has its difficulties. The theory of heat is not without its anomalies. The chemical theory of respiration is generally adopted, but there are facts that still oppose it. It is claimed by none, that the evidence of the law of evolution is complete, but it is a growing conviction of those who know the subject best, that the evidence in its favor preponderates overwhelmingly. Nor is it dependent upon any of its special interpretations. Darwin may be in error, Huxley may be wrong, Mivart may be wide of the mark, Haeckel may be mistaken, Cope may misjudge, and Spencer be at fault; but, in common with a large and increasing body of scientific men, they are all agreed as to one thing, that evolution is a great and established fact—a wide and valid induction from the observed order of Nature, the complete elucidation of which is the grand scientific task of the

future. It is in this sense that we hold to the doctrine of evolution.

In our prospectus we referred to the increasing number of those who desire to know whither inquiry is tending, what old ideas are perishing, and what new ones are rising into acceptance; and we said that our periodical was commenced with the intention of meeting the wants of these more perfectly than any other. The editor of *Scribner's* refers to this as a "magnificent promise," and dilates upon the transcendent editorial attributes required to realize it. To this we reply, "Not if the specimen of Scribnerian science we have here considered is to be taken as the standard." And if we may be permitted to imitate the bad example of *Scribner's* editor, and meddle for a moment with what is none of our business, we should say that he had better stick to his fiction and his verse-making, and not deviate into that foreign field where nothing is to be gained by cajoling public ignorance or catering to public prejudice, and where "the supreme concern is, to bring thought into the exactest harmony with things."

LITERARY NOTICES.

SPECTRUM ANALYSIS IN ITS APPLICATION TO TERRESTRIAL SUBSTANCES, AND THE PHYSICAL CONSTITUTION OF THE HEAVENLY BODIES. By Dr. H. SCHELLEN. D. Appleton & Co., 1872.

THE following able notice of Dr. Schellen's book is abridged from an article in *Nature:* It is not difficult to deliver interesting lectures or to write an instructive book on spectrum analysis. The rapid succession of brilliant discoveries in this new branch of science, the amount of fundamental facts added by it to human knowledge, especially in the field of the cosmical world, assure the lecturer or writer, appealing to the intelligent but not scientific public, of useful and legitimate success. But what is not so easy to do is, to interest at the same time the *gens du monde* and scientific men, by offering a selection of the most recent discoveries in a bright and literary form attractive to the former, and yet keeping for the latter the appearance of precision, and exactness of the numerical results. All these conditions are very happily filled in "Schellen's Spectrum Analysis," edited by Mr. W. Huggins from the second German edition.

The first part, introductory, is occupied by a description of the artificial sources of high degrees of heat and light, of which the study is so intimately connected with the chemical and astronomical phenomena embraced in the field of spectrum analysis; various apparatus, for instance, the gas-burner, the magnesium lamp, the Drummond lime-light, the electric spark of the induction coil, the Geissler's tube, and the electric light produced by voltaic batteries, are described, and the practical adjustments are briefly but sufficiently referred to for a good understanding of the subject.

The second part is devoted to an elementary abstract of the geometrical and mechanical properties of light. The fundamental analogy between light and sound is developed, in order to explain to a reader unlearned in optics how the color of a ray is the corresponding element of the pitch of a musical sound, and how it is possible to define a colored ray by the time of its luminous vibrations. The description of refraction phenomena, especially the paths of rays through a prism, leads naturally to the separating process of the different colors on which spectrum analysis is founded.

A considerable number of chapters is devoted to the construction of the simple and compound spectroscope. The chief points of this construction, especially the contrivances for the simultaneous comparison of two spectra, the determination of the position of lines in the spectrum, are carefully described. Afterward a practical account of the methods for exhibiting spectra of terrestrial substances, for instance, metallic salts volatilized in a gas-burner, etc., will certainly interest chemists.

An interesting chapter contains the theoretical and experimental explanation of the reversal of the spectra of gaseous substances. This phenomenon, studied independently by Foucault and Angström, and definitely generalized by Kirchhoff, is perhaps the chief point of the history of spec-

trum analysis, and certainly the beginning of its utilization as a powerful method of investigation.

The third part of the book, the most important in extent and results, is devoted to the application of the spectrum analysis to the heavenly bodies.

The sunlight, according to its brightness and to the peculiarities of its spectrum, is the best and easiest example to study. The dark lines in infinite number which it shows, called "Frauenhofer lines," from the discoverer, deserve special attention; therefore the author has illustrated the description of the sun-spectrum with two sets of maps. The first is a reduction of Kirchhoff's maps engraved on wood, representing in several tints the lines from *A* to *G*; the second series is a reduction to about half size of the admirable *normal solar spectrum* of Angström, in which the Frauenhofer lines from *a* to H_1 H_2 are coördinated according to their wave-lengths. The accuracy of these lithographic plates is really wonderful; they will have the great merit of introducing among physicists and astronomers the wave-length scale for the designation of lines instead of Kirchhoff's scale, which is an arbitrary one; and in any case they will facilitate the transformation of the data from one to another. I must add that Angström's maps have been introduced into the present edition by the English editor, and that such an addition is certainly one of the greatest attractions of this book for scientific men.

A good abstract of Kirchhoff's and Angström's memoirs on the coincidence of the dark solar lines with the bright lines of metallic vapors leads to the hypothetical constitution of the sun; this problem is so difficult, that it is necessary to leave to every one the responsibility of his own ideas on this subject.

The remaining part of the book is entirely devoted to the most delicate applications of spectrum analysis to astronomy. A preliminary description of the sun-spots, faculæ, and other peculiarities of the surface of the sun, of the prominences round the disk, and so on, is given before the spectroscopic process for analyzing these appearances is introduced, and enables the reader to understand very well the difficulties of the problem and the interest of its solution. I must mention especially the interesting account of the three total solar eclipses of 1868, 1869 and 1870. A large series of drawings and photographic facsimiles give the best idea of the phenomena, and show the improvements due to photography and spectroscopy; the relatively great extent devoted to this account is justified by the importance of the subject; the spectrum analysis of the prominences is in fact one of the most considerable results obtained for a long time in the science of cosmogony.

The spectroscope, as it is known, is able to give an exact measurement of the proper velocity of the luminous bodies. A German physicist, Doppler, deserves to be mentioned as the first who called the attention of astronomers to this subject, though a good number of his assertions may be incorrect. After him, Fizeau, a French physicist, to whom we are indebted for the first determinations of the velocity of light on the surface of the earth, showed the errors of Doppler in a little paper not very well known, published in 1849, and calculated the apparent change of refrangibility which would be produced by the proper motion of some heavenly bodies; but no direct experiment was made before the complete application of spectrum analysis to the sidereal phenomena. In this way Schellen's book gives a good abstract of the works of Huggins and Secchi. In these researches the velocity of rotation of the sun was to be tested as a verification of the general law of the phenomenon. I ought to say that the rather discordant results want a theoretical analysis, because the problem seems to me, in the case of the sun, more complicated than it appears at first sight. However, the influence of the velocity of the gas streams, especially of hydrogen, which constitute the greater part of the prominences, is unquestionably verified by Lockyer's observations. In the same way Huggins has proved and determined the proper motion of Sirius by the apparent change of refrangibility of the F line.

The remaining part of the book is devoted to stellar and meteoric spectrum analysis. It is impossible to give a superficial notice of the beautiful researches of Huggins and

Secchi, researches which are always going on; the reader will find with interest various important results of these studies—for instance, the existence in many stars of a good number of terrestrial substances—hydrogen, nitrogen, magnesium, sodium, etc.

One of the most interesting facts is the observation of the temporary star which appeared in May, 1866; the great brightness of the star was due, as indicated by the spectroscope, to an immense mass of incandescent hydrogen.

At the end of the work the author gives some very important observations of Huggins and others on the spectrum of nebulæ; the chief result is the possibility, with the aid of the spectroscope, of distinguishing by the composition of their light the true nebulæ from the clusters of stars.

Finally, a description of the spectrum of the aurora borealis, the identification of its bright lines with some bright lines of the solar corona, a description of various meteors, lightnings and their spectra, show into what difficult objects this new branch of science has pushed its investigations.

On the whole, this book must be considered as a good type of a "popular work;" it deserves the attention of the public, and the esteem of scientific men; and, finally, it recommends itself by a gracious side. It was translated into English by two ladies, who have had the double merit of giving a proof of their good scientific taste, and of showing an example of the help which their sex is able to afford to science.

LIFE IN NATURE.—MAN AND HIS DWELLING-PLACE. By JAMES HINTON. New York: D. Appleton & Co.

THESE works are unique in the scientific literature of the present time, and, although treating of different topics, are so characterized by a common spirit and method, that they may properly be considered together. Their author is a London surgeon in busy practice, but who has not permitted the pressure of professional duties to prevent him from giving close attention to the grave questions by which the mind of the age is agitated. Nor is Mr. Hinton a mere amateur who recreates with philosophy; he is a pioneer investigator in the field of science, and has occupied himself much with those new and large dynamical questions, and their various applications, with which scientific philosophers have been so intently engaged during the last quarter of a century. His inquiry into the physical conditions of vegetable growth, showing that it is governed by definite and traceable forces, and takes place in the direction of least resistance, like all mechanical effects, forms an important contribution to biological science, and was arrived at independently by Mr. Hinton and Herbert Spencer. Yet the author of these works has not dedicated himself to any line of special research (although from the fertility of his ideas, and the acuteness and originality of his views, he might, undoubtedly, have done so with eminent success); but, having mastered the more vital and comprehensive principles of modern research, he takes them as the starting-point for still larger views. Science, indeed, in its ordinary acceptation, is not to him an end. Though deeply imbued with its spirit, and equipped with its latest results, he is not satisfied to rest in this sphere of ideas: it is as leading to something beyond, or as furnishing a basis for something higher, that they have to him their principal value. As Bacon holds science subordinate to the ends of utility, and the practical service of humanity, Mr. Hinton would make it subordinate to the unfolding of man's spiritual nature. He prizes science chiefly for its religious uses, or as an interpretation of the divine order of the world. Maintaining the fundamental harmony of all truth, and that religion represents a verity of the universe as much as astronomy, he has taken it as his task to elucidate the harmonies that must prevail among the different aspects of truth in order that religious faith may be grounded in scientific principles. The results of science, and the knowledge we have of man and the external world, are the author's postulates; and from these he aims to pass, by unbroken logic, to the spiritual order of being. Holding Nature to be a sphere divinely designed for man's highest development, he admits no breaks in the order, and insists that the former must be understood before the latter can be determined. Science, therefore, according to Mr. Hinton, is

the foundation and prerequisite of man's true spiritual unfolding.

It has been made a criticism of Mr. Hinton's books, that their arguments are not fully sustained; or that, while their first portions are clear and cogent, the latter parts are indefinite and less conclusive. But this criticism attributes to defect in discussion that which is due to the nature of the subject-matter, for the ideas successively dealt with are so different as almost to appear contrasted. In the sphere of physical Nature, there are a definiteness, a quantitative sharpness, and a kind of tangibleness in the truths established, which disappear as we pass into the domain of moral and religious conceptions. This contrast of the phenomena in the two spheres, which are precisely conceived in the one case and not in the other, has been made the ground for denying that there can be any true science in the higher realm of man's moral and spiritual activity. But the objection is not valid; for, wherever there is an orderly and coherent body of truths, though they cannot be formulated with exactness, there is the legitimate basis of science. It may be long before the reconciliation and unification of unlike ideas and diverse systems of opinion will be completely accomplished; but it is no longer regarded as impossible, and every able attempt to realize it brings us a step nearer to the final and desirable result. Much is said, in these times, of the conflict of science and faith, and many maintain that they are invincibly hostile and must be permanently alienated. Mr. Hinton holds that this is an error due to the incompleteness and imperfection of present knowledge which the advance of thought is certain to correct, and all who read his works must confess that they are able and original contributions to this end.

"Life in Nature," aside from the higher purpose for which it was written, is one of the most charming studies in biology that our language affords. It abounds in interesting facts illustrating the beautiful laws of vital phenomena, and stated with unrivalled clearness, and is marked by keen and original insight into the old obscurities of the subject. The first chapter treats of "Function, and how we act;" the second of "Nutrition, and why we grow." The subsequent chapters take up the "Vital Force and Laws of Form," the "Universality of Life," "The Living World," "The Phenomenal and True," the "Organic and the Inorganic," and "Nature and Man." The volume is neatly illustrated, and we recommend it to all who care either for the strict science of the subject, or for the larger questions to which it leads.

"Man and his Dwelling-Place" was written fifteen years ago, has been recast, condensed, and made to embody the author's maturer views. Its perusal should follow that of "Life in Nature," as it deals with a higher range of questions, and is of a more speculative and metaphysical quality.

Mr. Hinton writes in a lucid, attractive, and eloquent style, and his books contain many passages of remarkable impressiveness and beauty. In the felicity of his delineations he often reminds one of Ruskin; but, unlike the great Rhapsodist of art, he is never run away with by his rhetoric. The intensity of his convictions and the earnestness of his feelings give warmth and force to his language, which is still chastened and restrained by the discipline of refined scholarship.

BOOKS RECEIVED.

Intermembral Homologies. The Correspondence of the Anterior and Posterior Limbs of Vertebrates. By Burt G. Wilder, S. B., M. D. Boston, 1871.

Apparatus for Electric Measurement, with Rules and Directions for its Practical application. By L. Bradley. Jersey City, 1872.

Proceedings at the Fifth Annual Meeting of the Free Religious Association. Held in Boston, May 30 and 31, 1872.

Papers relating to the Transit of Venus in 1874, prepared under the Direction of the Commission authorized by Congress, and published by Authority of the Hon. Secretary of the Navy. Washington, 1872.

A Classified Catalogue of the Birds of Canada, including every Species known to visit the Several Provinces which now form the Dominion of Canada. By Alexander Milton Ross. Toronto, 1872.

A Classified Catalogue of the Lepidoptera of Canada. By Alexander Milton Ross. Toronto, 1872.

Report submitted to the Trustees of Cornell University in behalf of a Majority of the Committee on Mr. Sage's Proposal to endow a College for Women. By Andrew D. White. Ithaca, 1872.

Report on the Climatology and Epidemics of Minnesota. By Charles N. Hewit, M. D. Philadelphia, 1872.

Short-hand and Reporting. A Lecture. By Charles A. Sumner, with Appendix. San Francisco, 1872.

MISCELLANY.

The Ground Connection of Lightning-Rods.—It is asserted, by all the later authorities on the subject of lightning-rods, that a proper ground termination of the rod is of the very first importance to its efficiency as a protection against accidents by lightning. The electricity of the cloud will select the easiest path into the earth, or, as it is technically stated, follow the line of *least resistance;* and it is to furnish a path less resisting than the building itself that the lightning-rod is erected. But it is not enough that the rod have a sufficient conducting capacity. The current must be able to leave it, at the place where it terminates in the ground, as fast as it passes along the rod, else there is an accumulation, or damming up as it were, in the rod, which, when it has attained a certain volume or intensity, will relieve itself with explosive violence; and thus the appliance becomes an actual source of danger to the building, rather than a means of protection. Mr. David Brooks, in an able paper on "Lightning and Lightning-rods," published in the August number of the "Journal of the Franklin Institute," says on this point: "I do not say that a greater proportion of buildings *having* lightning-rods are destroyed or injured than of those not having them, although those making careful observations do give that as a result of their statistics. I shall undertake to show that this difficulty *consists in the defective connection of these plates with the earth*, and also that with a proper connection with the earth they are almost, if not an absolute, means of protection." Says Prof. John Phin, in his admirable *brochure* on "Lightning-Rods and how to construct Them:" "Upon the perfection of the ground termination mainly depends the value of the lightning-rod. If this be defective, no other good features can possibly make up for it. And yet, so little is it understood, that a careful examination of a very large number of rods leads us to believe that fully one-half the lightning-rods in existence are defective in this respect, and consequently furnish but an insufficient protection."

All objects may be said to conduct electricity, but they vary greatly in their conducting capacity. Copper conducts six times as well as iron, and iron thousands of times better than water, and water again thousands of times better than dry earth. That is to say, a rod of iron, to have the same conducting capacity as a rod of copper, would require to be of six times the sectional area, while, if a rod or column of water were employed, it would require to be many thousands of times greater in sectional area than the iron, and dry earth again many thousands of times larger than the column of water. In connecting a rod with the ground, allowance has to be made for this difference in conducting capacity, sufficient earth-surface being joined to the rod to give a conducting capacity approaching to or equalling that of the rod. Otherwise the lightning discharge, unable to find a free passage into the ground, accumulates until the tension becomes so great that it bursts from the rod with explosive violence, taking the track which affords the readiest means of escape, and often doing serious damage in its progress.

Accidents of this character are by no means rare. Mr. Henry Wilde, in a communication to the *Mechanic's Magazine*, gives two cases of fire, resulting from the ignition of the gas by lightning in buildings where it left the conductor and took to the gas-pipes. In one instance, the discharge passed down a wire rope suspended by the side of a tall chimney, and, leaving the lower end of the rope, which was some ten feet from the ground, darted across a space of sixteen feet to a gas-meter in the cellar of an adjoining cotton-warehouse, where it

fused the lead-pipe connections, and set fire to the gas. In another instance, that of a church, provided with a lightning-rod, a lightning discharge left the rod at a point in close proximity to the gas-pipes, ignited the gas in the vestry, and the church was consumed. In a third case, the discharge descended a rod on a church-steeple, and, when within five feet of the ground, left the conductor, pierced a wall four feet thick, and disappeared in the gas-pipe under the floor of the church. Silliman's "Physics" gives a similar example, where, in a church in New Haven, the lightning has twice penetrated a twenty-inch brick wall at a point opposite a gas-pipe twenty feet above the earth, although the conductor, of three-quarter-inch iron, was well mounted, but its connection with the earth was less perfect than that of the gas-pipe.

It being established that the lightning will take the easiest track into the ground, it follows, from what occurred in each of the above cases, that the least-obstructed path was by way of the gas-pipes, with their extended ground connections. In the first example, although there was a lightning-rod on the chimney, the lightning took to the rope, and, instead of leaving it at the lower end for the rod, which was near by, found an easier passage through the air to the gas-pipes of the cotton-factory, which differed from the rod in having an extensive ground contact. The same was true in the other cases—the gas-pipes furnishing a readier path to the ground than the rods themselves. On account of the great surface contact with the ground, which gas and water pipes present, it has been recommended that lightning-rods be connected with these, as affording an excellent means for the escape of the electric discharge. At first glance, this might seem a dangerous expedient so far as gas-mains are concerned, the accidents above mentioned pointing to the danger of setting fire to the gas. This accident arose from the use of lead-pipe in making the connections with the meter. Had the gas-pipe throughout been of iron or brass, nothing of the kind could have occurred. Unmixed with atmospheric air, gas will not burn, and it was only through the melting of the lead-connections by the lightning that the gas was liberated and then ignited. Brass or iron pipes would have carried off the discharge without becoming fused, no gas would have been liberated, and no fire could have occurred. Commenting upon these accidents, Mr. Wilde says: "In my experiments on the electrical condition of the terrestrial globe, I have already directed attention to the powerful influence which lines of metal, extended in contact with moist ground, exercise in promoting the discharge of electric currents of comparatively low tension into the earth's substance, and also that the amount of the discharge from an electro-motor into the earth increases conjointly with the tension of the current and the length of the conductor extended in contact with the earth. It is not, therefore, surprising that atmospheric electricity, of a tension sufficient to strike through a stratum of air several hundred yards thick, should find an easier path to the earth by leaping from a lightning-conductor through a few feet of air or stone to a great system of gas or water mains, extending in large towns for miles, than by the short line of metal extended in the ground which forms the usual termination of a lightning-conductor."

But in the country no such system of gas and water pipes is at hand—the connection of the rod with the earth must therefore be made in some other way. On this point Mr. Brooks remarks: "Unless a hundred square feet of metal can be laid in the bed of a spring or body of water, I believe the building is safer without the lightning-rod." The advice generally given is to bury the lower end of the rod in charcoal or coke. Prof. Phin says, use coke, not charcoal; and, "whether iron or copper is employed, it will be well to sprinkle the coke copiously with a strong solution of washing-soda, for the purpose of neutralizing any acids that might corrode the metal. If a trench ten feet long be sunk to the depth of permanent moisture, and filled to a depth of twelve inches with coke, it will be ready to receive the end of the rod, and will furnish a path for all the electricity that will ever tend to escape from the clouds to the earth."

Foul Air.—The condition of the air commonly breathed in the workshop and school-

room is fairly indicated by the following statistics, the result of a large number of observations made by Mr. Richard Weaver in the schools and manufactories of Leicester, England: As carbonic-acid gas is usually the chief impurity in rebreathed air, being produced in large quantities by both breathing and combustion, Mr. Weaver takes it as the measure of aërial contamination, the amount present under ordinary circumstances enabling us to judge of the degree of vitiation caused by the other products of respiration and combustion. Setting out with the established fact that free or what is commonly called pure air contains, for every thousand parts, very nearly four-tenths of one part of carbonic acid, Mr. Weaver found in the air of a room where six persons worked at boot and shoe finishing, each person having 51 cubic feet of space, that the proportion of carbonic acid was 5.28 parts per thousand, or more than thirteen times as much as Nature, when let alone, allows. In another instance, where the air-space to each of fourteen individuals was 186 cubic feet, with fourteen gas-lights burning, the amount of carbonic acid, to a thousand parts of air, was 5.32. In a class-room of one of the national schools, and the science class-room at that, seventeen pupils, each with 200 cubic feet of space, were breathing an atmosphere containing 2.41 parts per thousand of carbonic acid, or six times as much as the air contains in exposed situations. In no case examined was the proportion of carbonic acid as low as one part in a thousand of air; the average in fifteen places being 3.14 per thousand, or nearly eight times as much as in pure air. It is hardly necessary to add that the provisions for ventilation, where any thing of the kind was attempted, were of the most imperfect character. But what may be effected by ventilation was strikingly shown in the instance of a boy's day-room in one of the national schools, where there were one hundred pupils, each with 236 cubic feet of air-space. The ventilators were placed in the roof, and, though very far from perfect, the air in the room contained only 1.16 parts of carbonic acid to the thousand, the lowest proportion observed in any of the fifteen cases examined. Mr. Weaver states that the atmosphere in several of the rooms was very offensive, and in every case a pleasurable sense of relief was experienced on entering the outer air. Large space, without ventilation, he considers of little avail, as it has no advantage over a small room except that the air is a little longer in attaining the same degree of contamination.

Careless Disinfection.—In cleansing and disinfecting rooms that have been occupied by persons sick with contagious diseases, mere exposure to disenfecting vapors is not enough to thoroughly rid the apartment of danger to future inmates. The floors and wood-work require thorough scouring with some disinfecting fluid, and the walls and ceiling should also be carefully cleaned. If the walls are covered with paper, nothing short of its removal will be effectual, as it unquestionably has the power of absorbing and retaining contagious matters, that are not reached by the ordinary processes of disinfection. And its removal is all the more necessary where several thicknesses are plastered on the wall, for then the deeper layers are quite beyond any possibility of being cleansed; and, apart from the danger of contagion, the presence of paste in such quantities, as several thicknesses of paper involve, liable in warm weather to ferment and decompose, and at all times furnishing a nest for hosts of vermin, is certainly most objectionable. That wall-paper does actually furnish lodgment for contagion, and the paste with which it is stuck on food for vermin, is proved by the following cases reported in the *Lancet*: The workmen engaged in stripping the paper from the walls of a house in Manchester, that had previously been occupied by persons ill with fever, nearly all came down with the same fever, although previous to their visit the house had been disinfected with chlorine and carbolic acid. In the Knightsbridge barracks, where numerous layers of paper and paste had been allowed to accumulate, the walls when examined were found to be literally swarming with maggots, that were leading a most flourishing existence while subsisting on the paste between the several thicknesses of paper. The practice of freshening the walls of rooms by covering up, instead of removing the filth, has become ex-

tremely common, hundreds of houses in this city being yearly rejuvenated in this way, to the serious injury, no doubt, of their subsequent inmates.

Trees and Rain.—A correspondent writes thus to the *Bulletin of the Torrey Botanical Club:* "The influence of trees upon rain and the general moisture of the atmosphere, which has been much discussed of late, receives a strong illustration from the island of Santa Cruz, West Indies. A friend who spent the months of February, March, and April last, upon this island, informs me that, when he was there twenty years ago, the island was a garden of freshness, beauty, and fertility. Woods covered the hills, trees were everywhere abundant, and rains were profuse and frequent. The memory of its loveliness called him there at the beginning of the present year, when, to his astonishment, he found about one-third of the island, which is about twenty-five miles long, an utter desert. The forests and trees generally had been cut away, rainfalls had ceased, and a process of desiccation, beginning at one end of the land, had advanced gradually and irresistibly upon the island, until for seven miles it is dried and desolate as the seashore. Houses and beautiful plantations have been abondoned, and the people watch the advance of desolation, unable to arrest it, but knowing almost to a certainty the time when their own habitations, their gardens, and fresh fields, will become a part of the waste. The whole island seems doomed to become a desert. The inhabitants believe, and my friend confirms their opinion, that this sad result is due to the destruction of the trees upon the island some years ago."

Poisonous Paper-Hangings.—In his valuable paper "On the Evil Effects of the Use of Arsenic in Certain Green Colors," published in the third annual report of the Massachusetts State Board of Health, Dr. Frank W. Draper gives the following, among other startling cases of arsenical poisoning from green-colored paper-hangings:

In 1862, a case of fatal poisoning under the conditions in question occurred in the suburbs of London, the victim being a child. The cause of death was made the subject of an investigation before a coroner's jury. In the course of the evidence, it transpired that the deceased was the last of four children who had died within a period of two months, under exposure to the poison contained in the paper-hangings of the room they habitually occupied. They had all been attacked in the same manner, the prominent symptoms being referred to the throat. The color was loosely applied, having no glazing. It was very deliquescent; at 50° it was quite damp, and the stain came off on the hand like paint. Three grains of arsenic were found in a square foot of the paper. The symptoms were attributed by the surgeon in attendance, Mr. Orton, and by Dr. Letheby, who made the *post-mortem* chemical examination, to arsenical poisoning.

But greens are not the only colors which contain arsenic, nor wall-paper the only fabric colored with arsenical pigments. A correspondent of the *Chemical News*, who is in a position to know, states that the French use the following-named pigments, containing arsenic, in calico-printing, and that they are equally suitable, and doubtless used, in the color of paper-hangings: *Light scarlet pigment* contained alumina, arsenious oxide, and aurine; *scarlet ponceau* contained carbonate of lime in addition to above ingredients; *dark green*, a preparation of aniline green and arsenious oxide; *steam chocolate*, and *catechu pigment*, both contained arsenious oxide. Hallwachs has demonstrated the presence of arsenic in red, as well as in green-colored wall paper.

Volcanic Dust.—The dust discharged at the last eruption of Vesuvius, though very heavy, was carried in one direction to a distance of twenty-five miles, where it fell in quantities sufficient to cause great annoyance to the inhabitants. It consisted of aggregations of crystallized quartz, dotted over with the magnetic oxide of iron. The grains were very uniform in size, and would pass through a wire gauze the apertures of which measured the sixteen thousandth of a square inch. By boiling in hydrochloric acid, the whole of the iron can be removed, and nothing but crystals of fine white quartz remain. Its composition is the same as that of the iron-sand which is found in the soil in some parts of the country round Vesu-

vius, and which is the product of former eruptions; the latter, however, contains a larger relative proportion of iron, and the grains show a water-worn appearance under the microscope. Neither of the Vesuvian specimens contains titanium, which is found in the magnetic iron-sand of New Zealand, which has most likely been ejected from the great volcano of Mount Egmont.

Transfusion of Blood.—Dr. Aveling reports in the *Lancet* a case where life was saved by the transfusion of blood, by what is known as the "immediate" method. The patient was a lady dying from hæmorrhage. Her pulse had become imperceptible both at the wrist and in the temporal arteries; the heart's action was very feeble, and steadily growing more so; she was insensible, with dilated pupils that refused to contract on the approach of a light; the extremities were cold, and the lips and face blanched. Blood was pumped, by means of a suitable apparatus, directly from a vein in the arm of a man, into a vein of the lady's arm, without exposure to the air, and in a duly-regulated stream. Some eight ounces of blood were thus transfused. As the operation proceeded, the pulse at the wrist became perceptible, the lips less blanched, and warmth returned to the hands. In a few hours consciousness returned, the patient took nourishment, and afterward fully recovered.

Habits of the Opossum.—We gather from the *American Naturalist*, for September, the following interesting particulars concerning the habits of the opossum: The animal is widely distributed in the United States. It dwells in hollow logs, stumps, and in holes at the roots of trees, does not burrow, but takes possession of holes that it finds ready made. Into these it will carry leaves—using its tail for the purpose—and provide itself with a comfortable bed, when bad weather threatens. It does not hibernate, but hunts its food at all seasons, is slow of foot, and not very wild. It will eat bacon, dry beef, carrion, any kind of fowl, rabbits, any sort of small game, almost all the insects, and fruits of every variety, being especially fond of muskmelons; and is eaten in turn by many people, the flesh being considered delicious. This has a flavor resembling that of the flesh of the young hog, but is sweeter and less gross. Negroes and others are exceedingly fond of it; dogs, however, hold a very different opinion, and will sooner starve than consume it. The animal is habitually incautious, and when attacked seems to possess little power of resistance; literally suffering itself to be eaten alive by the turkey-buzzards, while it lies on its side and protests against the proceeding by a succession of grunts. Exceedingly tenacious of life, it will survive a vigorous crunching by the dogs, when it seems as though every bone in its body had been cracked. Although sometimes found concealed under the floors of houses and out-buildings, it refuses to be domesticated, and is believed to dwell but a short time in any one place.

Dr. Carpenter against Materialism.—Dr. Carpenter, having been charged with attacking the philosophy of Profs. Huxley and Tyndall in his late address, replies, in a letter to the London *Echo*, as follows:

"Nothing was further from my intention than either to give a theological turn to my address, or to make any attack upon the philosophy of my two valued friends, whom I believe to be, in regard to most, if not all, of the philosophical questions I have treated, at one with me.

"But I did set myself to combat a mode of thought on scientific subjects which I know to be very prevalent among half-educated scientific men, who have never studied the constitution and working of their own minds, and which has been carried out most fully by a certain school of (so-called) Nature Philosophers in Germany. Of the tenets of this school, a small work by Dr. Buchner, entitled 'Kraft und Stoff'—Force and Matter—which has run through many editions, and has been translated into French, may be considered an exponent. The tenets are (I write from recollection, not having the book at hand) somewhat as follows:

"1. That we know, and can know, nothing of the external save matter, and the laws of matter.

"2. That these 'laws' are fixed, unchangeable, and self-acting.

"3. That there is consequently no ne-

cessity for a God, since Nature can do very well without one.

"4. That, if there be a God, he is limited in his action—just as man is—by the 'laws of matter,' which he can no more control than man can; and that he is, therefore, in his relation to Nature, only a higher kind of man.

"Now, my object was to show:

"1. That what we call 'laws of Nature' are simply our own expressions of the orderly sequence which we discern in the phenomena of the universe; and that, as all the history of science shows how erroneous these have been in the past, so we have no right to assume our present conceptions of that sequence to be either universally or necessarily true.

"2. That these so-called 'laws' are of two kinds, one set being mere generalizations of phenomena, of which Kepler's 'laws of planetary motion' or the 'laws of chemical combination' are examples, while another set express the conditions of the action of a force, of which the existence is, or may be, made known to us by the direct and immediate evidence of our own consciousness—our cognition of matter being indirectly formed through the medium of force.

"3. That 'laws' of the first kind (which we may for convenience term phenomenal) do not really explain or account for any thing whatever. Nothing is more common than to hear scientific men speaking of such laws as 'governing phenomena,' or of a phenomenon being 'explained' when it is found to be consistent with some one of such laws; though the fact is that the law is a law merely because it is a generalized expression of a certain group of phenomena; and to say that any new phenomenon is 'explained,' by its being shown to be in conformity to a 'law' is merely to say (as Prof. Clifford well put in his lecture) that a thing previously unknown is 'explained' by showing it to be like something previously known.

"4. That, on the other hand, every 'law' of the second kind (which we may distinguish as dynamical) is based on the fundamental conception of a force or power; so that if the existence of such a force (as that of gravity or electricity) be admitted, and the conditions of its action can be accurately stated, then the law which expresses them may be said to 'govern' the phenomenon; and any phenomenon, which can be shown to be necessarily deducible from it, may be said to be 'explained,' so far as science can explain it. But the utmost that science can positively do, as I stated toward the conclusion of my address, is to demonstrate the unity of the power of which the phenomena of Nature are the diversified manifestations, and to trace the continuity of its action through the vast series of ages that have been occupied in the evolution of the universe.

"5. I expressed the opinion that science points to (though at present I should be far from saying that it demonstrates) the origination of all power in mind; and this is the only point in my whole address which has any direct theological bearing. When metaphysicians, shaking off the bugbear of materialism, will honestly and courageously study the phenomena of the mind of man in their relation to those of his body, I believe that they will find in that relation their best arguments for the presence of infinite mind in universal Nature.

"Now, the only expression I have ever met with, in our own language, of the philosophy which (as I have said) worships the order of Nature as itself a God, was uttered by Miss Martineau, in the book on 'Man's Nature and Development,' which she produced some twenty years ago in conjunction with Mr. Atkinson. Not having the book at hand, I cannot cite any passage from it; but I well remember the general drift of its argument (putting aside mesmerism, phrenology, etc.) to have been that, whereas mankind formerly believed the phenomena of Nature to be expressions of the will of a Personal God, modern science, by reducing every thing to 'laws,' had given a sufficient 'explanation' of these phenomena, and made it quite unnecessary for man to seek any further account of them.

"This is precisely Dr. Buchner's position; and it seems to me a legitimate inference from the very prevalent assumption (which is sanctioned by the language of some of our ablest writers) that the so-

called laws of Nature 'govern' the phenomena of which they are only generalized expressions. I have been protesting against this language for the last quarter of a century; and, as I know that Dr. Buchner's views are extensively held among the younger thinkers of Germany and France, and have reasons to fear their extension to this country, I thought it well to take the opportunity which has been recently afforded me of calling the attention both of scientific men and of the general public to what I consider the true functions of man as the scientific interpreter of Nature. It was not because I had any thing to say on this subject that would be new either to men of science or to theologians, who have already gone through a like course of thought with myself, but because I hoped to lead some to think upon it who have never so thought before, and to help others to a clearer view of it than they might have themselves attained, that I chose it as the topic of my address. And, so far as I have the opportunity of judging, my hope is being fully realized."

Artificial Butter.—At the request of the victualling department of the French Navy for some wholesome substitute for butter that would keep well, Mege Mouriez, after a long course of experiments, has succeeded in producing an excellent substitute for genuine butter, that does not become rancid with time, and is otherwise highly recommended. Experiments made with cows, submitted to a very severe and scanty diet, led to the discovery that they continue to give milk, though in greatly diminished quantity, and that this milk always contains butter; whence it was inferred that this butter was formed from fat contained in the animal tissues, the fat undergoing conversion into butter through the influence of the milk-secreting glands. Acting on this hint, Mouriez's process begins with splitting up the animal fats. Finely divided fresh beef-suet is placed in a vessel containing water, carbonate of potash, and fresh sheep's stomachs, previously cut up into small fragments. The temperature of the mixture is then raised to about 112° Fahr., when, under the joint influence of the pepsin and the heat, the fat becomes separated from the cellular tissue. The fatty matter floating on the top is decanted, and after cooling submitted to very powerful hydraulic pressure. The semi-fluid oleo-margarine is thus separated from the stearine, and becomes the basis of the butter to be afterward produced. One hundred pounds of this oleo-margarine, along with about twenty-two quarts of milk and eighteen quarts of water, are poured into a churn, and to this mixture are added a small quantity of annatto and about three ounces of the soluble matter obtained by soaking for some hours in milk cows' udders and milk-glands. The mixture is then churned, and the butter obtained, after being well washed with cold water and seasoned, is ready for use. If required to be kept for a long time, it is melted by a gentle heat in order to eliminate all the water.

Ventilation and Warming.—In a lecture on ventilation, lately delivered before the Franklin Institute, Mr. L. W. Leeds, after detailing the abominations he encountered in his examination of the ventilating arrangements of the Treasury Building at Washington, gives the following practical directions concerning provisions for ventilation and warming in the construction of buildings. First, never have long underground fresh-air ducts. Second, never allow a sewer, soil-pipe, foul-air flue, or smoke-flue, to come near the fresh-air supply-flue, for fear of some connection being made between them by carelessness or accident. Third, never heat a building exclusively by currents of warm air. Fourth, always put the heating flues on the outside walls instead of on the inside walls. Fifth, endeavor strenuously to avoid the fresh-air chamber becoming a common receptacle for all the rubbish of a filthy cellar.

Sardines.—Mr. N. S. Dodge has given a very complete and interesting account of the "Natural History and Preparation of Sardines" in *Hearth and Home*, from which we gather the following: In natural history the sardine is the young of the pilchard, a fish resembling the herring in size, but thicker. They get the name of sardines, from having been formerly found in great quantities off the coast of Sardinia. They

make their appearance about the coast of the Armorican Peninsula early in spring, and succeed each other in countless shoals throughout the summer months. These shoals are marvellous for their size and the number of fish they contain. Each one takes the shape of a huge fish, bulging out toward the middle and tapering toward either end. The shoals vary from ten to thirty yards in width and from fifty yards to half a mile in length. The fish are sometimes so closely packed that numbers are constantly being shoved out of water. They are caught with nets, much in the same way as herrings, only the nets are provided with much smaller meshes. Although nets are employed, bait is also used. This bait is called *rogue;* and is imported in barrels from Norway.

In catching the fish, several boats go together, a man standing in the bow of each to give notice of the approach of a shoal. Upon the cry of "*Voila!*" the boats make for the head of the shoal, the nets are cast, and bait is thrown overboard. The fish in their eager pursuit after the bait get entangled in the net, when a second net is thrown out and the first one hauled in. When a boat is loaded, the fish are taken ashore and immediately sold. The process of preserving is as follows: As soon as the sardines are landed the greatest activity is necessary to get them "*sain et sauf*," since exposure to the air depreciates their freshness and much handling impairs their flavor. First, the fish are thoroughly washed and scraped, so as to free them from every impurity. They are then sprinkled with fine salt which crystallizes upon the surface and is almost immediately removed. Heads and gills are then taken off, a new washing undergone, and the fish laid to dry in the sunshine, on frames of wire or green withes. After drying they are thrown into caldrons of boiling olive-oil and cooked for two hours, when, after a second drying, they are transferred to the tables to be packed. Here women only do the work. To put the fish nicely in their places, to smother them with boiling oil, to fit the lid of the tin box, turn a jet of hot steam on the joints, and toss it hermetically sealed to the inspector, is but the work of a moment. Perhaps the one essential element in the curing of sardines is perfect olive-oil. If it be not entirely tasteless, it destroys what the Sardinians call the "*aramato*," the delicate, volatile flavor of the fish.

Sprats, shiners, roach, herrings, dace, and carp, when young, and with their heads off, have sufficient resemblance to sardines to pass for the genuine article. They are put up at various places on the southwestern coast of France, and are largely exported, probably comprising three-quarters of all that are sold in the United States under the name of sardines. When well cured, preserved in good oil, and hermetically sealed, these small fry are savory and palatable, but they lack the delicate volatile flavor of the real fish.

Ancient Engineering Among the Chinese.—The most remarkable evidence of the mechanical science and skill of the Chinese so far back as 1,600 years ago is to be found in their suspended bridges, the invention of which is assigned to the Han dynasty. According to the concurrent testimony of all their historical and geographical writers, Sangleang, the commander of the army under Baou-tsoo, the first of the Hans, undertook and completed the formation of the roads through the mountainous province of Shense, to the west of the capital. Hitherto its lofty hills and deep valleys had rendered the communication difficult and circuitous. With a body of one hundred thousand laborers he cut passages over the mountains, throwing the removed soil into valleys, and, where this was not sufficient to raise the road to the required height, he constructed bridges which rested on pillars or abutments. In another place he conceived and accomplished the daring project of suspending a bridge from one mountain to another across a deep chasm. These bridges, which were called by the Chinese writers, very appropriately, flying bridges, and represented to be numerous at the present day, are sometimes so high that they cannot be traversed without alarm. One still existing in Shense stretches four hundred feet from mountain to mountain, over a chasm of five hundred feet. Most of these flying bridges are so wide that four horsemen can ride on them abreast, and balustrades are placed on each side to protect travellers. It is by no means improba-

ble (as M. Panthier suggests), as the missionaries to China made known the fact more than a century ago that the Chinese had suspended bridges, that the ideas may have been taken thence for similar construction by European engineers.

NOTES.

THE *Spectator*, in its notice of M. Touchet's work, "The Universe," says: "Man generally flatters himself that his anatomy is about the highest effort of Divine skill; yet that of the insect is far more complicated. No portion of our organism can compare with the proboscis of the common fly. Man can boast 270 muscles. Lyonet, who spent his whole life in watching a single species of caterpillar, discovered in it 4,000. The common fly has 8,000 eyes, and certain butterflies 25,000. M. Touchet treats it as an established fact that so fine are the sensory organs of ants that they converse by means of their antennæ. Consequently the strength and activity of insects far surpass ours in proportion. In the whole field of natural science there is nothing more astounding than the number of times a fly can flap its wings in a second; it must in that point of time vibrate its wings five or six hundred times. But in rapid flight we are required to believe that 3,600 is a moderate estimate."

THE following, according to Prof. Palmieri, are the signs of an approaching eruption of Vesuvius: When the crater fills up and the vapor from it diminishes in quantity; when the vapor from the crater yields a heavy deposit of iron or sodium; when the water sinks in some of the springs of the neighborhood. The phenomena more nearly preceding an eruption are, the occurrence of earthquakes, increasing in intensity and frequency for some days beforehand; also the irregularity of the diurnal variations of the magnetic needle. One of the remarkable attendants of an eruption is the frequence of lightning flashes accompanying the condensation of vapor of water from the crater; just as in an ordinary thunder-storm lightning occurs at the time the vapor is condensing, as is proved by the rain that follows.

PROF. MUIR has been investigating the effects of various saline solutions on lead by suspending pieces of bright lead of of known area, each in a solution of known composition, for a given time, and then estimating the amount of lead dissolved, by Wanklyn and Chapman's color-test. He finds the greatest solvent power exerted by solutions of the nitrates, ammonium nitrate being especially active. The carbonates, as was before known, have the greatest protecting power, and next to them come the sulphates; so that, when either of these are present, even if the water contain a considerable proportion of nitrates, the solvent action on the lead is very slight.

IT is well known that all alloys containing copper, even in minute proportions, are readily acted on by acids, which makes them dangerous when used for household utensils. M. Helouis has proposed an alloy, under the name of platinum bronze, which is entirely inoxidizable. It is a nickel alloy, prepared from nickel made thoroughly pure by various processes and maceration in concentrated nitric acid. The proportions employed are nickel 100, tin 10, and platinum 1—the two latter metals being added to the fused nickel in the proportion of 4 of tin to 1 of platinum, and the remaining six parts of tin added subsequently. For bells and sonorous articles the proportions are slightly varied, viz., nickel 100, tin 20, silver 2, and platinum 1.

M. RENAULT has lately brought to the attention of the Paris Academy of Sciences a simple and effective method for reproducing drawings. The drawing is first made with sticky ink on highly-glazed paper, and afterward dusted with bronze-powder. Sheets of sensitized paper are then pressed upon the former, when the lines of the drawings are reproduced upon the paper by the chemical action which takes place between its sensitive surface and the metal. Impressions may be taken at any time, by softening the ink on the original with vapor of alcohol, and then redusting with the bronze-powder.

SULPHURIC acid, according to Dr. L. de Martin, when added to the sweet juice of the grape (*must*) in the proportion of from fifteen to forty-five grains of the concentrated acid to twenty-two gallons of *must*, exerts a favorable influence on the process of fermentation. The process is hastened and rendered more complete, and a better and more beautiful color is given to the wine. Analysis shows no more sulphuric acid in this wine than in samples not so treated. When the *must* is alkaline, as it sometimes is, the process of fermentation produces lactic acid instead of alcohol; hence the utility of sulphuric acid, which sets up the alcoholic fermentation of the sugar.

DR. VIRCHOW has been experimenting with reference to the influence of coal-gas on vegetation, when diffused through the soil. He finds, after a long series of carefully-conducted researches, that coal-gas is an active poison to vegetation, trees, shrubs and ornamental plants, being killed by it when it is allowed to permeate the soil about their roots.

GENERAL SIR EDWARD SABINE,

President of the Royal Society.